Three Essays on Public Procurement Auctions

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Outline

1. **Overview**
2. The Impact of Scoring Auctions in Public Procurement Auctions.
My dissertation consists of the following three studies:

1. I study the benefit of what is called a scoring auction over a standard (price-only) auction.

2. I study the effects of what is called an extra payment or cost overrun on the quality of work and the welfare, and the benefit of a scoring auction over the current procurement system.

3. I study the impacts of switching from an invited auction to an open auction to investigate whether competition or relaxing an entry regulation lower the quality of works.
Overview: The Impact of Scoring Auctions in Public Procurement Auctions.

Research questions:
- How much are SCRs better than STDs?
- When is using scoring auctions beneficial the most?

Methodology:
- I develop a structural model of a standard (price-only) auction which allows us to simulate the outcome of scoring auctions as a counterfactual scenario.

Estimation results and counterfactual simulations:
- The quality of work improves by more than 10% and the welfare gain for the government is about 5 – 7% under scoring auctions.
- The government is faced with more uncertainty for large-scale and complicated work.
- The increase of the standard deviation of the quality of work is larger for small-scale and simple work.
Overview: A Public Procurement Auction with the Presence of the Moral Hazard Problem: An Empirical Analysis.

Research questions:

- How much are the quality of work and the welfare for the government decreased when extra payments are reduced?
- How much are the quality of work and the welfare for the government improved when scoring auctions are implemented?

Methodology:

- I develop an auction model with the moral hazard problem to consider the presence of extra payment as an incentive scheme to improve the quality of work.
- I develop a structural estimation model based on the auction model which allows us to compute the above two counterfactual scenarios.

Estimation results and counterfactual simulations:

- The welfare loss is 40% when extra payments are reduced by 50%.
- Compared with the current procurement system, the quality of work improves 5% and the welfare gain is 5% under a scoring auction.

Research questions:
- Does competition or relaxing entry regulations worsen the quality of works? I empirically investigate this question based on a comparison between an INVITED and an OPEN.
- When are implementing OPENs more beneficial?
  - the presence of efficient new participants.
  - the difference in the contract sizes.

Methodology:
- the IV method and the difference-in-difference.

Estimation results:
- For large-scale contracts, introducing open auctions reduces by up to 34% in terms of the final payments because the presence of new participants induces aggressive bidding behavior.
- For small-scale contracts, open auctions do not bring about the reduction of procurement costs.
- We do not observe the trade-off between the procurement costs and the quality of works.
Outline

1. Overview
2. The Impact of Scoring Auctions in Public Procurement Auctions.
Summary: Motivation

Facts and a real situation:

- Public sector procurement accounts for 13-20% of GDP on average worldwide.
- Not only standard auctions but also scoring auctions are typically used: the U.S, Japan, the E.U and some developing countries.
  - a standard (price-only) auction (STD) or a first price sealed bid auction (FPA): a bidder with the lowest bid price is the winner.
  - a scoring auction (SCR): the winning bidder is determined based on both her bid price and quality level.
Overview

The 1st Paper

The 2nd Paper

The 3rd Paper

SCR vs STD

Standard Auction ⇒ Price is the only index

Firm A → Price → Winner in the auction

Scoring Auction ⇒ Winner is determined by “score”

Firm A → Price → Score: Quality/Price or Price + Working days → Winner in the auction

Quality!
⇒ working days,
technology used for the contract,
the quality level
Summary: Literature

1. Few empirical papers investigate the benefits of SCRs over STDs.
   - Lewis and Bajari (2011 QJE): the usage of the OLS to show SCRs > STDs in terms of the quality of work and the commuter gain. In that paper, the quality of work is measure by the completion time.

2. Fact: The government tends to use SCRs to award large-scale, difficult and complicated contracts in the U.S and Italy while recently, the Japanese government adopts scoring auctions for all of the contracts.

3. There are no works theoretically and empirically discussing when using scoring auctions is the most beneficial.
Summary: Research Question

The research questions of this paper are as follows:

1. How much is better for SCRs relative to STDs? by using the quality scores
2. When using scoring auctions is more beneficial?:
   - large-scale and complicated work vs small-scale and simple work:
We develop a structural model of a standard auction to quantify the benefit of SCRs over STDs without using data of scoring auctions.

A similar approach is applicable to the investigations of two different SCRs using a dataset of one type of SCR and other counterfactual scenarios such as auctions with investments to the qualities.

The information on the finished condition of work and the work execution process are included in the quality score of work reviewed after the completion of work in the dataset.

Our method can achieve the identification of general forms of cost functions to improve the quality of works.

We provide two sources to generate the potential benefit of using scoring auctions and quantify the effects.

The difference of the marginal costs to improve the quality of works and the uncertainty of the winning bidders’ private information for the government’s perspective.

Quantification of the differential impacts of scoring auctions between large-scale and complicated work and small-scale and simple work.
Public Procurement Auctions Held by the MLIT

A first price sealed bid (price-only) auction with a secret reserve price.

- The reserve price is not publicly announced at the time of bidding. After the bids are opened, the reserve price is publicly announced.

Our dataset includes the following information in each auction:

- the reserve price, the appraisal value
- the winning bid
- the quality score of work
- the number of bidders
Public Procurement Auctions Held by the MLIT 2

About the quality score of the work in STDs:

- After the completion of public work contract, engineers in the MLIT review the quality of work.

- The quality score of work is based on the finished condition of work, the quality of work, the work progress control, the execution management, the safety management and the schedule control (up to this constitute more than 70% of the score), the consideration to the environment, the ingenuity for the execution of work, the ability of engineers, the technology level used for the work and the legal compliance.
The firm’s expected profit function in the STD is written as follows:

\[ \pi(b, Q|\theta) = [b - C(Q, \theta)]\text{Prob}(\text{Win}|b) \]

- **b**: bid price
- **\(C(Q, \theta)\)**: cost function, **Q**: the quality level, **\(\theta\)**: the cost parameter.
- Each firm is assumed to be symmetric.
- They draw their cost parameters **\(\theta\)** from an independent and identical distribution \(F_\theta(\cdot)\) defined on \([\theta, \bar{\theta}]\).
Theory 2

The cost function is assumed to be $C_{\theta}(Q, \theta) > 0$ and $C_Q(Q, \theta) > 0$.

where

$$C(Q, \theta) \quad \text{where} \quad Q \in [\underline{Q}, \overline{Q}]$$

The procedure of the equilibrium bid price and quality is as follows

1. Fixing the bid price “b”, the firm determines the quality level “Q”.
2. Provided the quality level “Q”, the equilibrium bid price for the bidder is derived as in the standard auction model.

This procedure is the same as Che(1993) and Asker and cantillon(2008)
For the quality level:

\[ Q = \max_Q \left( \min_{\theta} C(Q, \theta) \right) \quad Q \in [\underline{Q}, \overline{Q}] \]

- The quality level is the lowest level of quality that satisfies the government requirement. Contractors only follow specifications and plans determined by the government. No incentive to improve the quality level suggested by the government.

- We then consider the optimization problem of the bidder as in the standard auction model based on \( c \equiv C(\underline{Q}, \theta) \).
Identification and Estimation 1

Following GPV(2000), we have the relation between “c” and “w”:

\[ C(Q, \theta_{1:N}) = w - \frac{(1 - G_W(w))(1 - H(w))}{\frac{N-1}{N} g_W(w)(1 - H(w)) + (1 - G_W(w))h(w)} \]

where \( G_W(\cdot) \) is the distn fn of winning bids, \( g_W(\cdot) \) is the density fn of winning bids, \( H(\cdot) \) is the distn fn of reserve prices and \( h(\cdot) \) is the density fn of reserve prices.

We have the cost estimate \( c = C(Q, \theta) \) and \( Q \) because \( w, G_W(\cdot), g_W(\cdot), H(\cdot), h(\cdot) \) and \( N \) are observable from the dataset!

How to identify (know) the form of the cost function: \( C(Q, \theta) \)?
- We assume \( C(Q, \theta) = \theta Q + \alpha \).
- However, there are two unknowns in spite of an equation.
Identification and Estimation 2

Figure: **Identification**: \((\theta, \alpha)\)

On the left side: not sufficient information to determine \(\theta\) and \(\alpha\) uniquely.
The key of identification is to exploit a property that \( Q \) vary across auctions while \( \theta \) and \( \alpha \) do not.

We have \((Q, c)\) and \((Q', c')\) at time \( t \) (some short period).

\[
\text{where } c = C(Q, \theta) \text{ and } c' = C(Q', \theta). c, c' \sim F(c).
\]

At time \( t \), we assume that a firm wins 2 contracts with the same type of works (the costs to complete the works are almost the same and the same cost function is required to conduct the works while the location of work is different.).

The quality score of work \( Q \) varies across auctions at time \( t \) due to the variation of the location of work.

\( c \) varies across contracts due to the variation of \( Q \).

We have \( c = \theta Q + \alpha \) and \( c' = \theta Q' + \alpha \) and obtain \( \theta \) and \( \alpha \) by solving the simultaneous equation.

This method can be applied to more general cost functions
\[
(\theta Q^S + \alpha_{s-1}Q^{s-1} + \ldots + \alpha_1Q + \alpha_0 (s \geq 2 \& \alpha_s > 0 (s = 2, ..., S))).
\]
Identification and Estimation 4

- It is difficult to find the same firms due to the characteristics of the dataset.

- We choose \((c_1, Q_1)\) and \((c_2, Q_2)\) which are contracts with the closest-scale estimated costs and within 6 month for the difference of the auction date.
  - the closest-scale estimated costs: the contract values are close and the same form of cost function is required to complete the work.
  - 6 month: the form of a cost function remains unchanged.

- Small business set aside policy. Small (large) firms with the small (large) number of engineers enter small (large) projects.

- We can interpret the each firm who have \((c_1, Q_1)\) and \((c_2, Q_2)\) show (approximately) the same cost function.

- We find the combinations of \((c_1, Q_1)\) and \((c_2, Q_2)\) for each type of works.

- We find about 350 combinations for bridge work and about 100 combinations for painting work.
The Theory of Scoring Auction 1 (introduced by Che (1993 Rand))

- We derive the equilibrium bid price and quality under the scoring auction developed by Che (1993 Rand) for the counterfactual scenario.
- The scoring rule $S(b, Q)$ is given by $S(b, Q) = V(Q) - b$:
- Each bidder chooses $(b, Q)$ that maximize his or her expected profit:

\[
\max_{(b, Q)} [b - C(Q, \theta)] \text{Prob}(\text{Win}|s) \text{ sub to } s = V(Q) - b
\]

- The equilibrium quality $Q_S(\theta)$ is derived as follows:

\[
Q_S(\theta) \in \arg\max_Q V(Q) - C(Q, \theta)
\]

- $V(Q) - C(Q, \theta)$ represents the welfare for the government.
The Theory of Scoring Auction 2 (introduced by Che(1993 Rand))

- We then define: \( k = V(Q_S(\theta)) - C(Q_S(\theta), \theta) \) which is called pseudo type.

\[
(k - s) F_k(\beta^{-1}(s))^{N-1}
\]

- We reinterpret the problem for a bidder as one where each bidder determine \( s \) according to \( k \) and the equilibrium bid function \( \beta(\cdot) \). We then have the following expected profit function:

The equilibrium bid price is:

\[
b(\theta) = C(Q_S(\theta), \theta) - \int_k^k \left[ \frac{F_k(t)}{F_k(k)} \right]^{N-1} dt
\]

When we assume \( V(Q) = a \log Q \), the equilibrium quality is:

\[
Q_S(\theta) = \frac{a}{\theta} \in \arg\max_Q a \log(Q) - (\theta Q + \alpha)
\]

- The equilibrium quality \( (Q_S(\theta)) \) increases in the marginal cost \( (\theta) \).
Theory: the Government

How to obtain the form of $V(Q)$?

- The government sets the reserve price $r$ to maximize her expected surplus:

  $$r \in \text{argmax}_r \ E[(v_B - W)1(W \leq r)] \text{ where } W = \sigma(c_{1:N})$$

- where $v_B$ is the value of a contract for the government.
- The government’s optimal strategy is truth telling and $v_B = r$.
- We need the functional form of $V(Q)$. We make assumptions to obtain $V(Q)$.

  - $V(Q) = a\log Q$
  - “Q” is assumed to be $Q$ observed in the dataset.

We calculate $a$ in each auction by using $v_B(= r)$ and $Q$. 


We see the Figures for bridge work and painting work to compare those works.

We normalize the cost parameters by the estimated costs to consider the difference of the cost parameters between the two of the works.

We provide two approaches to consider the difference of cost functions.

- We consider the difference of the forms of cost functions in terms of the marginal cost per estimated cost ($\theta_t / c_t$) and the fixed cost per estimated cost ($\alpha_t / c_t$).
- We calculate the variances of $\theta_t / c_t$ to show the uncertainty of $\theta_t$ for the government.

See Figure.
Estimation Result 2

Figure: Comparison between Bridge Work and Painting Work

Table: The Variance of theta/hatc for Bridge Work and Painting Work

<table>
<thead>
<tr>
<th>Painting Contract Size</th>
<th>theta/hatc (std dev)</th>
<th>Bridge Contract Size</th>
<th>theta/hatc (std dev)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>1.13</td>
<td>70</td>
<td>0.01</td>
</tr>
<tr>
<td>71</td>
<td>0.04</td>
<td>71</td>
<td>0.18</td>
</tr>
<tr>
<td>72</td>
<td>0.10</td>
<td>72</td>
<td>0.08</td>
</tr>
<tr>
<td>73</td>
<td>0.05</td>
<td>73</td>
<td>0.19</td>
</tr>
<tr>
<td>74</td>
<td>0.06</td>
<td>74</td>
<td>0.14</td>
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<tr>
<td>75</td>
<td>0.06</td>
<td>75</td>
<td>0.24</td>
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<td>76</td>
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<tr>
<td>78</td>
<td>0.14</td>
<td>78</td>
<td>0.09</td>
</tr>
<tr>
<td>79</td>
<td>0.02</td>
<td>79</td>
<td>0.08</td>
</tr>
<tr>
<td>80</td>
<td>Non</td>
<td>80</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Figure: Comparison between Bridge Work and Painting Work
Results, Counterfactual Simulations and Conclusion

- When SCRs are implemented to bridge work, the welfare gain for the government is **5.5%** and the quality of work rises by **14%** on average compared with standard auctions.

- With regard to painting work, under scoring auctions, the welfare gain for the government is **3.6%** and the quality of work increases by up to **11%** relative to STDs.

- The uncertainty of $\theta/c$ is larger for bridge work → effective to use scoring auctions to induce bidders to reveal their private information.

- The difference in the cost functions: the difference in the scope to execute ingenuity and increase the quality of work.

- The standard deviation of the quality of work rises by 8.07 point ($3.67 \rightarrow 11.74$) for painting work while that of the quality of work increases by 7.55 point ($4.59 \rightarrow 12.14$) for bridge work.
Outline

1. Overview
2. The Impact of Scoring Auctions in Public Procurement Auctions.
Motivation 1

Facts and a real situation:

- In public procurement (especially, public-work projects and defense programs), the discrepancies between winning bids and final payments frequently arise: the U.S, Japan, Italy and Turkey. The presence of extra payments (cost overruns) is frequently reported.

- This is inconsistent with the thought of auction (no favorism and no discretion).

- The G7 countries including Japan and the U.S are faced with fiscal deficits and huge government debt.
  - → Some more effective procurement systems are required.
The ex post changes of initial plans and payments frequently arise because initial plans and designs are inadequate due to the lack of sufficient practical experiences, information and knowledge about geological conditions and actual constructions for public officers and design engineers.

For some projects, the extra payment is provided to support the quality of work when the government adjusts the inadequate initial plan.
Motivation 3 Literature

1. Few empirical papers investigate the effects of extra payments and ex-post adaptations in public procurement. Theory:
   - Bajari and Tadelis (2001 Rand): a trade-off between transaction costs and giving incentives to limit costs.

Empirics:
   - Bajari, Houghton and Tadelis (2014 AER): the structural estimation of transaction costs due to the incomplete contract.
   - Lewis and Bajari (2014 RES): the moral hazard due to the ex-post adaptations.

2. However, they do not consider the moral hazard problem, especially the relation between the quality of work and the extra payment in the process of bidding. In addition, empirical investigations of how to improve the current procurement system remain scarce.

3. Empirical investigations of scoring auctions are also limited except for Lewis and Bajari (2011 QJE).
Research Questions

1. How much are the quality of work and the welfare for the government are decreased when extra payments are reduced?

2. How much are the quality of work and the government welfare improved when scoring auctions are implemented?
Contributions

I develop an auction model to combine the moral hazard problem and the standard auction model to show a new interpretation of the presence of extra payment as an incentive scheme to improve the quality of work.

- In the dataset, the final payment and the quality score of work reviewed after the completion of work are included in spite of the standard auctions.

I develop a structural estimation model based on the auction model which allows us to consider the following two counterfactual scenarios.

- The first is the investigation of the outcomes when the government reduces the extra payment.
- The second is the effects of introducing scoring auctions. There have been few empirical work examining the impacts of using scoring auctions.
Public Procurement Auctions Held by the MLIT 1

- A first price sealed bid (price-only) auction with a secret reserve price.
- Our dataset includes the following variables:
  - the reserve prices, the appraisal values
  - winning bids, final payments (the extra payments)
  - the quality scores of works
  - the number of bidders
Theory 1

A two stage game:

- The final payment is assumed to be written by an implicit linear contract: $b + E(\gamma)Q$.
- The expected value of $\gamma E(\gamma)$ is assumed to be common among all bidders and the government at the time of bidding.
- If a contractor is selected, she chooses a level of quality “$Q$”. The payoff function conditional on winning is written as

$$b + E(\gamma)Q - C(Q, \theta)$$

- We derive the equilibrium quality:

$$\max_Q E(\gamma)Q - \theta Q^2 - \alpha \iff Q^* = \frac{E(\gamma)}{2\theta}$$

- We consider the firm’s optimization problem based on

$$c \equiv -E(\gamma)Q^*(\theta) + C(Q^*(\theta), \theta).$$

We regard $c \sim F(\cdot)$ as the private information for bidders at the auction model.
Theory 2

The equilibrium bid is determined by

$$\max_b \pi(b, Q^*(\theta)|\theta) = [b - c] \text{Prob}(\text{Win}|b)$$

By following GPV(2000), the equilibrium bid price of this model is:

$$w = C(Q^*(\theta_{1:N}), \theta_{1:N}) - E(\gamma)Q^*(\theta_{1:N}) + \frac{(1 - G_W(w))(1 - H(b))}{\frac{N-1}{N} g_W(w)(1 - H(w)) + (1 - G_W(w))h(w)}$$

- where $c = C(Q^*(\theta_{1:N}), \theta_{1:N}) - E(\gamma)Q^*(\theta_{1:N}) = \alpha - E(\gamma)^2/4\theta_{1:N}$
- where $G_W(\cdot)$ is the distribution function of the winning bids, $g_W(\cdot)$ is the corresponding density function, $H(\cdot)$ is the distribution function of the reserve prices.
Identification and Estimation of the Auction Model

In this model, there are two FOCs and two unknown structural parameters \((\alpha, \theta_{1:N})\) in the system of two linear equations:

\[
\alpha - \frac{E(\gamma)^2}{4\theta_{1:N}} = w - \frac{(1 - G_W(w))(1 - H(w))}{\frac{N-1}{N} g_W(w)(1 - H(w)) + (1 - G_W(w)h(w))}
\]

\[
Q^*(\theta_{1:N}) = \frac{E(\gamma)}{2\theta_{1:N}}
\]

where \(w, Q, G_W(\cdot), g_W(\cdot)\) and \(H(\cdot)\) are observable from the dataset!

The identification of the structural model is achieved by solving the simultaneous equation.
The quality when the extra payment is decreased

In addition to the scoring auction developed by Che (1993), we consider the quality of work and the welfare loss when the extra payment is decreased. The equilibrium quality when extra payment is decreased is written as:

$$\max_Q kE(\gamma) Q - \theta Q^2 - \alpha \leftrightarrow Q^{**}(\theta) = \frac{kE(\gamma)}{2\theta}$$

where $0 < k < 1$. We show

$$\frac{kE(\gamma)}{2\theta} < \frac{E(\gamma)}{2\theta}$$

where the moral hazard problem is shown. We then have the cost estimate by putting $Q^{**}(\theta) \equiv kE(\gamma)/2\hat{\theta}$ into $C(\cdot, \hat{\theta})$.

$$C(Q^{**}(\theta), \theta) = \alpha - \frac{k^2 E(\gamma)^2}{4\theta}$$
The government set the reserve price $r$ to minimize her expected cost:

$$E[(V(Q) - E(\gamma)Q - \sigma(c_{1:N}))1(\sigma(c_{1:N}) \leq r)].$$

- $V(Q) - E(\gamma)Q = r$ because the government's optimal strategy is truth telling.
- “$Q$” and “$E(\gamma)$” are observed in the dataset (the extra payment).
- We assume $V(Q) = a\log Q$. We can calculate $a$. 
Estimation Result

<table>
<thead>
<tr>
<th>Contract size</th>
<th>num of obs</th>
<th>alpha/cost evaluated at 70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1341</td>
<td>0.84</td>
</tr>
<tr>
<td>~50 million yen</td>
<td>182</td>
<td>0.68</td>
</tr>
<tr>
<td>50~100 million yen</td>
<td>543</td>
<td>0.83</td>
</tr>
<tr>
<td>100~200 million yen</td>
<td>488</td>
<td>0.90</td>
</tr>
<tr>
<td>200 million yen~</td>
<td>100</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Table:

- The magnitude of marginal cost is decreasing in the contract values while that of fixed cost is increasing in the contract values.
Results, Counterfactual Simulations and Conclusion

- The outcomes in the current FPAs when extra payments are decreased.
  - The quality of work and the government welfare monotonically decreased in the extra payment.

- I simulate that the welfare loss is 40% when extra payments are reduced by 50%.

- I show that compared with the current procurement system, the quality of work improves 5% and the welfare gain is 5% under the scoring auction developed by Che(1993).

- SCRs > the current procurement system (about 0.7%-15%)
Outline

1. Overview
2. The Impact of Scoring Auctions in Public Procurement Auctions.
Summary: Motivation 1

Facts and a real situation:

- Entry regulations are common worldwide (doctors, lawyers, imported goods...).

- The presence of new low-quality participants may lower the quality levels while competition can improve the efficiency and lower the prices.

- The government is concerned not only with the efficiency and the prices but also with the quality levels because medical errors, fraud schemes and imported poisoned foods can lead to dismal outcomes.

- Not only open auctions but also invited (restricted) auctions are typically used: Japan, the E.U and some developing countries.
  - an open auction (OPEN): any prospective bidders can voluntarily participate in the auction if they satisfy the minimum restrictions such as financial conditions.
  - an invited (restricted) auction (INVITED): only bidders who are selected by the government are allowed to participate in the auction.
OPEN vs INVITED 2

Open Auction

- Actually participating firms (1~40)
- Firms satisfying the restriction (100?)
- About 500,000 firms
- Responsible firms in the market operated by the MLIT (100~5000)

Invited Auction

- Actually chosen firms (8~15?)
- Potentially chosen firms (10~100?)

Winners
## Summary: OPEN vs INVITED 3 and Motivation 2

### Comparison Between Invited and Open Auction

<table>
<thead>
<tr>
<th></th>
<th>ADVANTAGE</th>
<th>DISADVANTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPEN</td>
<td>Any firms who satisfy the minimum restrictions can voluntarily participate in the auctions ⇒ close to market mechanism ⇒ efficient outcomes</td>
<td>The presence of inexperienced bidders ⇒ the worsening of the quality of work</td>
</tr>
<tr>
<td>INVITED</td>
<td>Exclude incompetent bidders prior to auctions ⇒ maintain the quality of work</td>
<td>Bidders are selected by the government ⇒ inefficient outcomes bidding rings</td>
</tr>
</tbody>
</table>

Some empirical papers quantify the benefits of OPENs over INVITEDs and the presence of new participants only in terms of the winning bids.: Ohashi (2009 RIO) De Silva Dunne and Kosmopoulou (2003 JIE) and De Silva, Kosmopoulou and Lamarche (2009 J Pub E)

However, final payments and the quality of work are not used. In addition, we do not know when using the OPENS benefit the most.

The ex-post adaptations are investigated in some empirical researches.: Bajari, Houghton and Tadelis (2014 AER) and Lewis and Bajari (2014 RES). So considering final payments and the quality of works reviewed after the completion of works are important. Soft budget constraint.
The research questions of this paper are as follows:

1. Does competition or relaxing entry regulations lower the quality of work? We empirically examine this based on a comparison between an INVITED and an OPEN.

2. When using OPENs are beneficial the most?
   - the presence of new efficient participants
   - the difference in the contract sizes
Summary: Contribution

There are two main contributions in the paper.

- **We investigate whether competition or relaxing an entry regulation worsen the quality of works by quantifying the impacts of open auctions over invited auctions.**
  - For the empirical research, I obtain a unique dataset which includes the information on the final payment and the quality score of work reviewed after the completion of work in addition to the number of bidders, the winning bid, the contract days and the final working days in each auction.
  - The quality score includes the information on the finished condition of work, the quality of work and the execution management in addition to the information on the completion time.

- **We examine when introducing open auctions is benefit the most in terms of not only the procurement costs but also the quality of works.**
  - the presence of new efficient participants
  - the difference in the contract size
The Change of Bidder Qualification Process 1

The introduction of open auctions:
- From April 2001 to September 2006, Koizumi cabinet promoted fiscal reconstruction.
- In October 2004, in public procurement auctions operated by the MLIT, large-scale collusive activities were detected and a number of senior officials in the MLIT and executives in the construction industry were arrested.
- As a result, the introduction of open auctions to contracts worth 730 million yen or less was proposed.

The introduction of scoring auctions:
- Scoring auctions are introduced by the establishment of bill for ensuring the quality of public works in 2005.
- Scoring auctions are also introduced in the descending order in the contract values.
The Change of Bidder Qualification Process 2

- The period of analysis: 2005.4-2008.3.
- There are 4 auction methods: OPEN SCRs, OPEN STDs, INVITED SCRs, INVITED STDs.
- Therefore, we need to find regions where the single treatment approaches are valid.
- We use the dataset at Kanto, Shikoku, Kyusyu (contracts worth more than 100 mils yen) and Kinki (contracts worth 50 mils yen or less).
  - Kanto: 2006.6 - 2007.3 vs 2007.6 - 2008.3
  - Kyusyu: 2006.4 - 2006.6 vs 2007.4 - 2007.6
  - Kinki: 2005.4 - 2005.6 vs 2006.4 - 2006.6
The Change of Bidder Qualification Process 3

**Figure:** Policy Change in Public Procurement Auction Held at Regional Bureaus

**Timeline:**
- 2005.11: Kinki: road maintenance and repairs
  - Invited Standard
- 2006.4: Kinki: road maintenance and repairs
  - Invited Standard
- 2007.4: Kinki: road maintenance and repairs
  - Open Standard Invited Standard
- 2005.11: Shikoku: asphalt paving, bridge, road and river construction and repairs
  - Invited Standard
  - Invited Scoring
  - Open Scoring
- 2006.4: Shikoku: asphalt paving, bridge, road and river construction and repairs
  - Open Scoring
- 2007.4: Shikoku: asphalt paving, bridge, road and river construction and repairs
  - Open Scoring
- 2005.11: Kanto and Kyusyu: asphalt paving, bridge, road and river construction and repairs
  - Invited Standard
  - Open Scoring
- 2006.4: Kanto and Kyusyu: asphalt paving, bridge, road and river construction and repairs
  - Invited Scoring
  - Open Scoring
- 2007.4: Kanto and Kyusyu: asphalt paving, bridge, road and river construction and repairs
  - Open Scoring

Introduction of open auction
The Definition of New Participants in Open Auctions

A new participant in open auction does not submit his bids in the period of invited auctions.

A new participant submits his initial bid in the period of our analysis.

The participant submits his bid at the subsequent auction ⇒ new participant.

Figure: The Definition of New Participants
Summary Statistics 1 (procurement costs and quality of work)

We see the summary statistics at Kanto, Shikoku, Kyusyu and Kinki.

Table 2: Summary Statistics for Kanto and Shikoku Regional Bureau

<table>
<thead>
<tr>
<th>Variable</th>
<th>Kanto Invited</th>
<th>Kanto Open</th>
<th>Kanto Open w/ new</th>
<th>Kanto Open in 05</th>
<th>Kanto Open w/ wins by new</th>
<th>Shikoku Invited</th>
<th>Shikoku Open</th>
<th>Shikoku Open w/ new</th>
<th>Shikoku Open in 05</th>
<th>Shikoku Open w/ wins by new</th>
</tr>
</thead>
<tbody>
<tr>
<td>reserve price</td>
<td>1.50E+08</td>
<td>1.52E+08</td>
<td>1.47E+08</td>
<td>1.59E+08</td>
<td>1.54E+08</td>
<td>2.57E+07</td>
<td>1.66E+08</td>
<td>1.60E+08</td>
<td>1.74E+08</td>
<td>1.59E+08</td>
</tr>
<tr>
<td>rel win bids</td>
<td>0.87</td>
<td>0.89</td>
<td>0.88</td>
<td>0.87</td>
<td>0.89</td>
<td>0.92</td>
<td>0.90</td>
<td>0.93</td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>rel fin pay</td>
<td>1.08</td>
<td>1.13</td>
<td>1.12</td>
<td>1.34</td>
<td>1.07</td>
<td>0.92</td>
<td>1.07</td>
<td>1.15</td>
<td>1.02</td>
<td>0.92</td>
</tr>
<tr>
<td>cost overrun</td>
<td>0.24</td>
<td>0.26</td>
<td>0.27</td>
<td>0.34</td>
<td>0.29</td>
<td>0.26</td>
<td>0.49</td>
<td>0.52</td>
<td>0.49</td>
<td>0.60</td>
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<td>quality score</td>
<td>74.65</td>
<td>75.48</td>
<td>75.42</td>
<td>75.72</td>
<td>74.24</td>
<td>74.62</td>
<td>74.62</td>
<td>74.62</td>
<td>75.25</td>
<td>75.25</td>
</tr>
<tr>
<td>completion time</td>
<td>0.72</td>
<td>0.62</td>
<td>0.49</td>
<td>0.62</td>
<td>0.70</td>
<td>0.62</td>
<td>0.52</td>
<td>0.62</td>
<td>0.62</td>
<td>0.60</td>
</tr>
<tr>
<td>potential # bidders</td>
<td>8.00</td>
<td>6.10</td>
<td>5.46</td>
<td>5.39</td>
<td>5.55</td>
<td>11.03</td>
<td>8.78</td>
<td>7.73</td>
<td>7.73</td>
<td>4.75</td>
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<td>obs</td>
<td>273</td>
<td>267</td>
<td>65</td>
<td>46</td>
<td>17</td>
<td>31</td>
<td>86</td>
<td>26</td>
<td>29</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure: Summary Statistics on Kanto and Shikoku
Summary Statistics 2 (procurement costs and quality of work)

Table 3: Summary Statistics for Kyusyu and Kinki Regional Bureau

| Variable           | Kyusyu  |          |          |          |          |          |          |          |          |
|--------------------|---------|----------|----------|----------|----------|----------|----------|----------|
|                    | Invited | Open     | Open w/ new | Open in 06 | Open w/ wins by new |
| reserve price      | 1.46E+08| 1.48E+08 | 1.50E+08 | 1.57E+08 | 1.13E+07 |
| rel win bids       | 0.87    | 0.88     | 0.88     | 0.88     | 0.90     |
| rel fin pay        | 1.13    | 1.16     | 1.09     | 0.90     | 0.49     |
| cost overrun       | 0.30    | 0.37     | 0.23     | 0.43     | 0.49     |
| quality score      | 73.18   | 74.53    | 75.10    | 74.40    | 75.40    |
| completion time    | 0.21    | 0.50     | 0.53     | 0.64     | 0.64     |
| potential # bidders | 15.32  | 15.45    | 16.77    | 17.68    | 17.80    |
| obs                | 22      | 64       | 30       | 25       | 5        |

| Variable           | Kinki   |          |          |          |          |          |          |          |
|--------------------|---------|----------|----------|----------|----------|----------|----------|
|                    | Invited | Open     | Open w/ new | Inv in 06 | Open w/ wins by new |
| reserve price      | 2.75E+07| 3.19E+07 | 3.22E+07 | 2.50E+07 | 1.48E+07 |
| rel win bids       | 0.91    | 0.90     | 0.90     | 0.85     | 0.14     |
| rel fin pay        | 1.17    | 1.19     | 1.22     | 1.20     | 0.42     |
| cost overrun       | 0.29    | 0.33     | 0.37     | 0.41     | 0.36     |
| quality score      | 68.77   | 68.96    | 68.65    | 68.38    | 3.10     |
| completion time    | 0.01    | 0.02     | 0.00     | 0.00     | 0.00     |
| potential # bidders | 8.36   | 5.04     | 6.00     | 8.63     | 4.41     |
| obs                | 132     | 68       | 40       | 24       | 13       |

Figure: Summary Statistics on Kyusyu and Kinki
## The Degree of Competition in Invited Auctions 1

<table>
<thead>
<tr>
<th>Kanto</th>
<th># of Open 05-07</th>
<th># of Invited 05-07</th>
<th># of responsible bidders in 05</th>
<th>The Ave # of invited bidders in each invited</th>
<th># of new participants</th>
<th>the total # of invited bidders</th>
<th># of winning/ # of invitations in open auctions</th>
<th># of winning/ # of participations</th>
</tr>
</thead>
<tbody>
<tr>
<td>road c &amp; r</td>
<td>189</td>
<td>351</td>
<td>1636</td>
<td>9.2</td>
<td>51</td>
<td>628</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td>river c &amp; r</td>
<td>203</td>
<td>427</td>
<td>1636</td>
<td>9.8</td>
<td>38</td>
<td>535</td>
<td>0.1</td>
<td>0.14</td>
</tr>
<tr>
<td>bridge c &amp; r</td>
<td>113</td>
<td>111</td>
<td>1636</td>
<td>8.9</td>
<td>62</td>
<td>314</td>
<td>0.11</td>
<td>0.13</td>
</tr>
<tr>
<td>paving A</td>
<td>181</td>
<td>190</td>
<td>40</td>
<td>10</td>
<td>8</td>
<td>70</td>
<td>0.09</td>
<td>0.25</td>
</tr>
<tr>
<td>paving B</td>
<td>41</td>
<td>127</td>
<td>560</td>
<td>9</td>
<td>8</td>
<td>238</td>
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<td>0.19</td>
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<td>road m &amp; r</td>
<td>176</td>
<td>437</td>
<td>4986</td>
<td>8.5</td>
<td>17</td>
<td>846</td>
<td>0.08</td>
<td>0.4</td>
</tr>
<tr>
<td>river m &amp; r</td>
<td>185</td>
<td>536</td>
<td>4986</td>
<td>9.9</td>
<td>23</td>
<td>813</td>
<td>0.08</td>
<td>0.2</td>
</tr>
<tr>
<td>bridge m &amp; r</td>
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<td>101</td>
<td>4986</td>
<td>7.9</td>
<td>27</td>
<td>219</td>
<td>0.1</td>
<td>0.23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shikoku</th>
<th># of Open 05-07</th>
<th># of Invited 05-07</th>
<th># of responsible bidders in 05</th>
<th>The Ave # of invited bidders in each invited</th>
<th># of new participants</th>
<th>the total # of invited bidders</th>
<th># of winning/ # of invitations in open auctions</th>
<th># of winning/ # of participations</th>
</tr>
</thead>
<tbody>
<tr>
<td>road c &amp; r</td>
<td>184</td>
<td>68</td>
<td>633</td>
<td>10.5</td>
<td>27</td>
<td>189</td>
<td>0.1</td>
<td>0.13</td>
</tr>
<tr>
<td>river c &amp; r</td>
<td>205</td>
<td>83</td>
<td>633</td>
<td>10.4</td>
<td>36</td>
<td>176</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>bridge c &amp; r</td>
<td>66</td>
<td>25</td>
<td>633</td>
<td>10.4</td>
<td>42</td>
<td>117</td>
<td>0.11</td>
<td>0.16</td>
</tr>
<tr>
<td>paving A</td>
<td>84</td>
<td>15</td>
<td>21</td>
<td>11.7</td>
<td>1</td>
<td>16</td>
<td>0.09</td>
<td>0.17</td>
</tr>
<tr>
<td>paving B</td>
<td>37</td>
<td>10</td>
<td>217</td>
<td>7.6</td>
<td>8</td>
<td>32</td>
<td>0.14</td>
<td>0.18</td>
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<tr>
<td>road m &amp; r</td>
<td>162</td>
<td>83</td>
<td>2400</td>
<td>9.8</td>
<td>20</td>
<td>212</td>
<td>0.09</td>
<td>0.21</td>
</tr>
<tr>
<td>river m &amp; r</td>
<td>56</td>
<td>28</td>
<td>2400</td>
<td>10</td>
<td>25</td>
<td>169</td>
<td>0.1</td>
<td>0.16</td>
</tr>
<tr>
<td>bridge m &amp; r</td>
<td>44</td>
<td>15</td>
<td>2400</td>
<td>10.5</td>
<td>31</td>
<td>75</td>
<td>0.1</td>
<td>0.16</td>
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</table>

**Figure:** The Degree of Competition at Kanto and Shikoku
### The Degree of Competition in Invited Auctions

#### Figure: The Degree of Competition at Kyusyu and Kinki

<table>
<thead>
<tr>
<th>Kyusyu</th>
<th># of Open 05-07</th>
<th># of Invited 05-07</th>
<th># of responsible bidders in 05</th>
<th>The Ave # of invited bidders in each invited</th>
<th># of new participants</th>
<th>the total # of invited bidders</th>
<th># of winning/ # of invitations</th>
<th># of winning/ # of participations</th>
</tr>
</thead>
<tbody>
<tr>
<td>road c &amp; r</td>
<td>388</td>
<td>226</td>
<td>931</td>
<td>11.6</td>
<td>59</td>
<td>440</td>
<td>0.11</td>
<td>0.1</td>
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<tr>
<td>river c &amp; r</td>
<td>429</td>
<td>250</td>
<td>931</td>
<td>11.4</td>
<td>74</td>
<td>419</td>
<td>0.1</td>
<td>0.09</td>
</tr>
<tr>
<td>bridge c &amp; r</td>
<td>261</td>
<td>100</td>
<td>931</td>
<td>11.1</td>
<td>90</td>
<td>100</td>
<td>0.1</td>
<td>0.08</td>
</tr>
<tr>
<td>paving A</td>
<td>110</td>
<td>46</td>
<td>38</td>
<td>15.3</td>
<td>18</td>
<td>35</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>paving B</td>
<td>119</td>
<td>70</td>
<td>344</td>
<td>10.9</td>
<td>47</td>
<td>177</td>
<td>0.1</td>
<td>0.13</td>
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</table>

<table>
<thead>
<tr>
<th>Kinki</th>
<th># of Open 05-07</th>
<th># of Invited 05-07</th>
<th># of responsible bidders in 05</th>
<th>The Ave # of invited bidders in each invited</th>
<th># of new participants</th>
<th>the total # of invited bidders</th>
<th># of winning/ # of invitations</th>
<th># of winning/ # of participations</th>
</tr>
</thead>
<tbody>
<tr>
<td>road m &amp; r</td>
<td>177</td>
<td>433</td>
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<td>river m &amp; r</td>
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<td>6990</td>
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<td>82</td>
<td>711</td>
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<td>0.21</td>
</tr>
</tbody>
</table>
We estimate the IV models at the auction-level. Hence, the estimation model is written at auction $a$ in time period $t$.

- The 1st stage regression is given by:

$$D_{at} = \beta_1 + \beta_2 Z_t + X'_{at} \beta_3 + \epsilon_{at}$$  \hspace{1cm} (1)

- The 2nd stage regression is given by

$$Y_{at} = \alpha_1 + \alpha_2 D_{at} + X'_{at} \alpha_3 + \epsilon_{at}$$  \hspace{1cm} (2)

- We are interested in $\alpha_2$. Similar results are obtained through the D-I-D.
### Estimation Result 1

<table>
<thead>
<tr>
<th>Region</th>
<th>ln winning bid Coef.</th>
<th>ln winning bid S.E</th>
<th>ln final payment Coef.</th>
<th>ln final payment S.E</th>
<th>completion time Coef.</th>
<th>completion time S.E</th>
<th>quality score of work Coef.</th>
<th>quality score of work S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shikoku</td>
<td>open -0.075 ** 0.043</td>
<td>-0.275 ** 0.133</td>
<td>-0.080 0.259</td>
<td>0.043 3.427</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>obs 117</td>
<td>117</td>
<td>117</td>
<td>117</td>
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<tr>
<td></td>
<td>R-squared 0.95</td>
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<td></td>
<td></td>
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<tr>
<td>Kyusyu</td>
<td>open -0.081 0.077</td>
<td>-0.344 * 0.203</td>
<td>-1.363 ** 0.541</td>
<td>2.163 4.299</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>obs 86</td>
<td>86</td>
<td>86</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>R-squared 0.85</td>
<td>0.52</td>
<td>0.00</td>
<td>0.21</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Kanto</td>
<td>open 0.007 0.014</td>
<td>0.011 0.037</td>
<td>-0.750 ** 0.297</td>
<td>-0.528 0.676</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>obs 540</td>
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<td>540</td>
<td>540</td>
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<tr>
<td></td>
<td>R-squared 0.82</td>
<td>0.46</td>
<td>0.29</td>
<td>0.07</td>
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<tr>
<td>Kinki</td>
<td>open -0.061 0.074</td>
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<td>-0.244 *** 0.043</td>
<td>-2.861 * 1.553</td>
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</tr>
<tr>
<td></td>
<td>R-squared 0.97</td>
<td>0.86</td>
<td>0.13</td>
<td>0.72</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure:** The Estimation Results by the IV method
We estimate the IV models at the auction-level. Hence, the estimation model is written at auction $a$ in time period $t$.

- The 1st stage regression is given by:

$$D_{at} = \beta_1 + \beta_2 Z_t + X'_a t \beta_3 + \epsilon_{at} \tag{3}$$

- The 2nd stage regression is given by

$$Y_{at} = \alpha_1 + \alpha_2 D_{at} + X'_a t \alpha_3 + \epsilon_{at} \tag{4}$$

- $D_{at}$ takes 1 when new participants participate in auction $a$ and time $t$ and 0 otherwise.
### Estimation Result 5

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shikoku</td>
<td>OLS</td>
<td>ln winning bid</td>
<td>-0.014</td>
<td>0.026</td>
<td>ln final payment</td>
<td>-0.080 **</td>
<td>0.039</td>
<td>completion time</td>
<td>-0.049</td>
<td>0.085</td>
<td>quality score of work</td>
<td>0.870</td>
<td>1.263</td>
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<td></td>
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<td>Kyusyu</td>
<td>IV</td>
<td>ln winning bid</td>
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<td>0.124</td>
<td>ln final payment</td>
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<td>0.428</td>
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**Figure:** The Estimation Results for new participants
Results and Conclusion

For the government,

- basically, OPENs > INVITEDs
  - the winning bid: 4% - 8%
  - the final payment: 7% - 34%
  - the completion time: not changed.
  - the quality score of work: not changed.

- Large-scale contracts > small-scale contracts.

- This result is due to the presence of new participants. Especially, when new participants participate in the auctions, the final payment is decreased by up to 75%. This result is consistent with Maskin and Riley (2000 RES)

- We find No trade-off between procurement costs and the quality of works. Soft budget constraint?