Entry Deterrence in Procurement Auctions

Yuki Ito

University of California, Berkeley

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Motivation

Procurement auction is a widely used tool:

- Exploit competitive behavior and allocate projects efficiently

In competitive environments, impact of information disclosure may be substantial (Milgrom 2008)

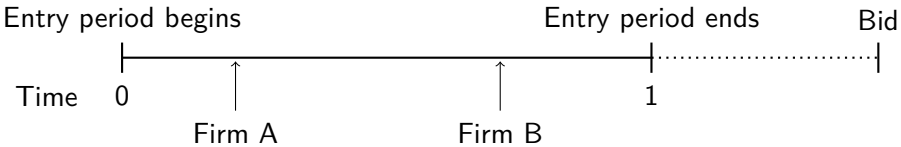
Entry disclosure:

- Pre-communication before entry decisions has impacts on market outcomes (Farrell 1987)
- If entry is costly, a firm's entry disclosure may deter entry from others

We study how entry disclosure affect market outcomes by studying procurement auctions

Trade-off of Entry Disclosures

Procurement auction: Sealed-bid first price auction



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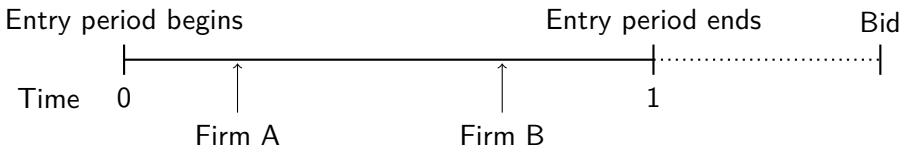

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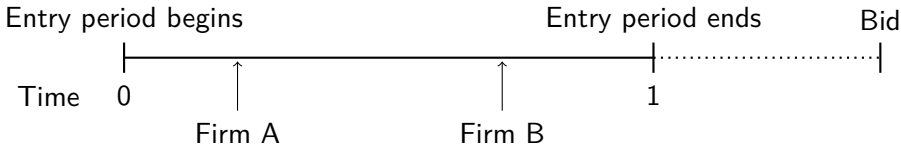

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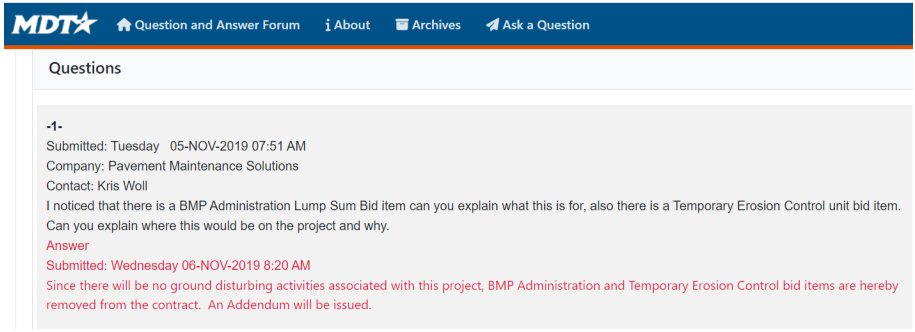
Inviting in More Aggressive Bids:

- If Firm B also enters,
  - Firm B is certain about A's entry

    $\Rightarrow$ B may bid more aggressively than in the case where A was silent

Procurement Auctions: Montana Department of Transportation

- Sealed-bid first price auction, where the lowest bid wins and gets paid the lowest bid
- Entry is costly: document preparation and negotiation with subcontractors
- Would there be entry disclosure...?
- Unique feature: Q&A forum gets continuously updated



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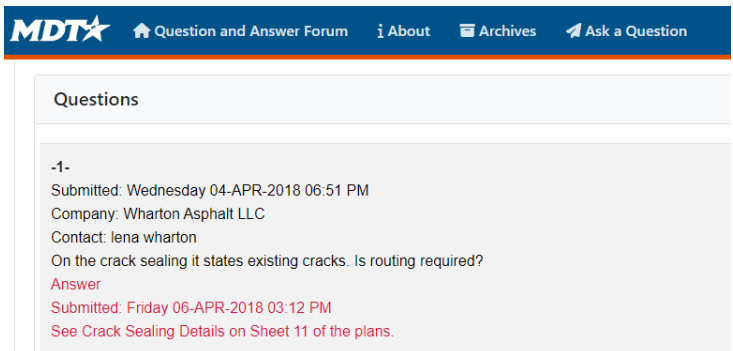

MDOT: Q&A forum as entry disclosure device

We consider Q&A forum as an entry disclosure device

Posted questions serve as a ***credible signal*** of entry

- $> 99\%$ of questions come from actual entrants
- "*It's safe to assume that contractors would not be asking questions unless they are going to bid the project.*"

Questions are posted ***strategically***:

- "*There is always a* ***strategical consideration*** *to the questions we ask and is* ***not solely determined by us needing the information***. *It can be gamesmanship with the other bidders.*"

The Economic Impact of Q&A Forum (Entry Disclosure)

The world spent 12% of global GDP (>\$10T/yr) on public procurement (Bosio et al. 2022)

Our estimates suggest: Introduction of Q&A forum **reduces** government's payment by **6.3%**.

Suppose 10% of public procurement is done through first price auctions

- Back-of-the-envelope calculation suggests:
- Introducing a Montana-like Q&A forum would reduce payment by **\$70B** worldwide

This Paper

Descriptive evidence – Correlation patterns

- Disclosure & entry prob.; Disclosure (timing) & bids

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Build a model of procurement auction with costly entry and option to disclose entry

- Firms sequentially and randomly arrive at the market
- Firms make decisions on entry AND disclosure, before bidding
- Trade-off of disclosure:
  - $(+)$ Entry deterrence v.s. $(-)$ Inviting in more aggressive bids
- *Methodological contribution:* Non-parametric identification of the model

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- *Methodological contribution:* Non-parametric identification of the model

Estimate the model to quantify the value of disclosure and disclosure device

- Auctioneer's payment, Efficiency (winner's cost & entry cost)

Overview of Results

Value of disclosure for a bidder:

- **Early** disclosure is **beneficial**, while **last minute** disclosure is **costly**

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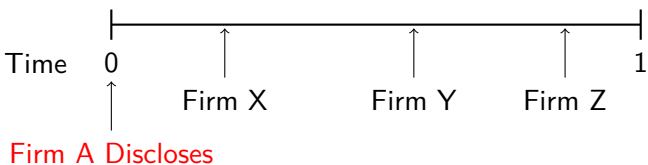

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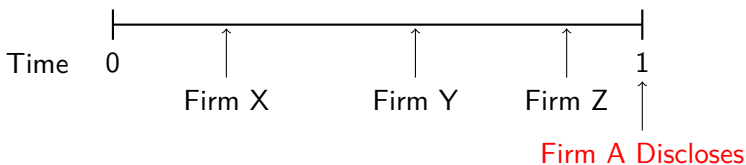

- If Firm A discloses at $t = 0$, A may deter entry from Firms X, Y, and Z.
- If Firm A discloses at $t = 1$, A cannot deter entry from others.

  $\Rightarrow$ Deterrence effect diminishes over time

  Trade-off: (+) Deterrence vs. (-) Inviting in More Aggressive Bids

Overview of Results

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Disclosure also provides info on strength of firms:

- **Stronger** bidders (low construction costs) are more likely to disclose

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Introduction of the device **decreases** auctioneer's payment by 6.3%

- Firms give up information to deter entry
  Information rent $\downarrow \rightarrow$ payment $\downarrow$
- Firms can coordinate entry behavior
  Firms enter w/ high likelihood when likely to have small #entrant
  #Auctions with small #bidder $\downarrow \rightarrow$ payment $\downarrow$

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Introduction of the device **increases** winner's construction cost by 4.5%

- Asymmetry in beliefs: Disclose vs Not disclose $\Rightarrow$ inefficient winners: winner's cost $\uparrow$

▸ Asymmetric beliefs

Related Literature

1. Strategic entry deterrence:
   - Theory: Salop (1979); Dixit (1980); Milgrom & Roberts (1982); Bernheim (1984); Farrell (1987)
   - Empirical: Morton (2000); Goolsbee & Syverson (2008); Ely & Hossain (2009); Ellison & Ellison (2011); Sweeting et al. (2020)

   → This paper: Study entry disclosure as a tool to deter entry

2. Auctions with costly entry:
   - Ye (2007); De Silva et al. (2008); Ely & Hossain (2009); Li and Zheng (2009, 2012); Krasnokutskaya & Seim (2011); Athey et al. (2011); Athey et al. (2013); Roberts (2013); Roberts & Sweeting (2013); Bhattacharya et al. (2014); Gentry & Li (2014); Quint & Hendricks (2018)

   → Incorporating costly entry is important for understanding auction outcomes

   → This paper: Study how the option to disclose entry affect outcomes

Outline

MDOT Procurement auction: Setting

Procurement: Construction projects

A sealed-bid first price auction: lowest bid wins and gets paid the lowest bid

- Question becomes publicly observable immediately after getting posted
- $> 99\%$ of Qs come from actual entrants
  - We will assume firms post Qs only if they enter
- The set of entrants is not announced until the final result gets revealed
  - Firms do NOT know the exact set of entrants when they bid

Data

Our data covers auctions from 2017 – 2022

Bids:

- All bids with identity of the firm, Engineer's (government's) estimate of total cost
  - We normalize the bids by the estimated cost
- 434 auctions
- 12.5 *potential* entrants, 2.85 *actual* entrants on average
  - potential entrant: placed a bid at lease once within same (district,type)-pair
- Median estimated cost: $\$1.3$M

Q&A forum:

- Identity of the firm, Timestamp for when the question was posted
- 0.83 Qs per auction on average

Outline

Descriptive Evidence: Entry Deterrence

If disclosure deters others' entry (**Entry Deterrence**)

- *Negative* correlation btw Q being posted from others and entry prob.

Entry prob. of firm who see Qs is **lower**:

- than those who see none by 14% (3.4pp)

▸ Unobs. heterogeneity in proposal ▸ Sample: did not ask ▸ By number of Q

Descriptive Evidence: Inviting in More Aggressive Bids

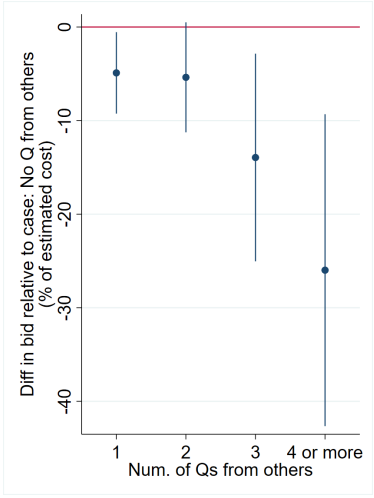
If others' disclosure affects your bidding behavior (**Inviting in More Aggressive Bids**)

- *Positive* correlation btw facing Q from others and strength of own bid

Bidders who face Qs make **more aggressive** bids

- Seeing one more Q is related with a **more aggressive** bid by 4%* of estimated cost

▸ Q as info



Timing of Q: Entry Deterrence vs. Inviting in More Aggressive Bids

Best bid from opponents is **weaker** for a firm who post a Q **early** $(t = 0)$ than:

- those who never post by 8% of estimated cost

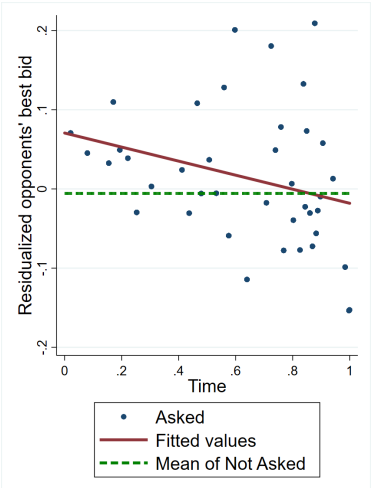
Best bid from opponents is **stronger** for a firm who post a Q **at the last minute** than:

- those who never post by 1% of estimated cost

In light of the trade-off...

- Early disclosure:
  Deterrence $>$ Inviting in more aggressive bids
- Late disclosure:
  Deterrence $<$ Inviting in more aggressive bids

▸ Q as info



Outline

Model: Trade-off of Entry Disclosure

We consider a game where firms sequentially decide whether they enter the auction:

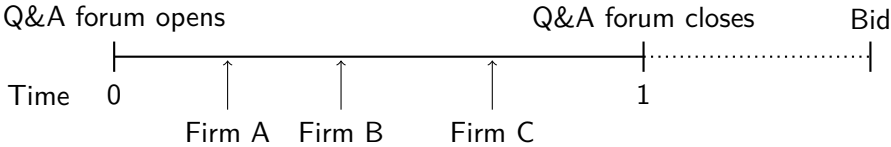
- Firms observe the Q&A forum, i.e., disclosures, before deciding whether they enter
- Entry disclosure is ***credible***

Trade-off for disclosure:

1. May deter entry of firms who are still on the sideline
2. Entrants may bid more aggressively b/c they know that you are in

Model

Firms randomly arrive at the market within time $[0, 1]$ w/o knowing when others arrive



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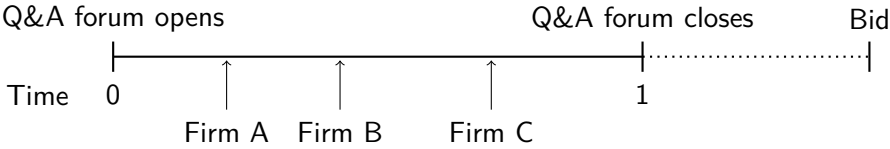

When a firm arrives at $t = \tau$, they make decisions at $t = \tau$ in the following order:

(1) (2) (3):**If they enter**

Observe disclosures

A sees nothing

B sees if A disclosed

C sees if A/B disclosed

Draw entry cost c_i^E

Decide enter/not enter

Draw construction cost c_i

(a) With prob. p^Q,
MUST disclose w/o cost

(b) With prob. $1 - p^Q$:
Draw disclosure cost c_i^Q
Decide disclose/not disclose

Model: Second stage – Bid

- Entrants observe if A/B/C disclosed
- Entrants bid b_i simultaneously

Payoff of firm i is:

$$\pi_i = (b_i - c_i)\mathbb{1}\{i \text{ wins}\} - c_i^E \mathbb{1}\{i \text{ enters}\} - c_i^Q \mathbb{1}\{i \text{ discloses}\}$$

Equilibrium

We consider Perfect Bayesian Equilibrium of this game.

Requirements (given consistent beliefs):

- Enter iff expected value from entry $>$ cost of entry (c_i^E)
- Disclose iff expected value of disclosure $>$ cost of disclosure c_i^Q
- Bid b_i that max. expected profit, cond. on entire disclosure history h^T and constr. cost c_i

$$b_i = \arg\max_b \mathbb{E}[(b - c_i)\mathbb{1}\{i \text{ wins}\}|h^T, c_i]$$

Outline

Identification: roadmap I

We provide non-parametric identification results:

Dist'n of (i) arrival timing; (ii) entry costs; (iii) disclosure costs; and (iv) constr. costs.

Challenge in identification: Arrival timing is observed *only* for those who posted a Q

1. Construction costs c_i and dist'n of construction costs F_c
   - Follow Guerre, Perrigne, & Vuong (2000), exploiting optimality of bids

▸ Primitives

Identification: roadmap II

2. Firm's beliefs on evolution of Q history: $\Pr^i(h^T|h^\tau, \tau_i = \tau, \text{ disclose/not disclose})$
   - If i discloses, belief $\Pr^i(h^T|h^\tau, \tau_i = \tau, \text{ disclose})$ is directly identified from data
   - If i does not disclose, belief $\Pr^i(h^T|h^\tau, \tau_i = \tau, \text{ not disclose})$ is identified by:

Identification: roadmap II

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Suppose that two firms i and j have not disclosed under h^τ.

- Consider the time until the first disclosure after h^τ:
- This is the minimum of two objects:
  - Time until i discloses if j stays silent
  - Time until j discloses if i stays silent
- Dist'n of these two objects are identified
  - Exploiting idea from survival analysis literature
  - Events: disclosures; Competing risk: multiple firms
- Dist'n of the latter object is what we want

Primitives

Identification: roadmap III

3. Value fn with/without disclosure and value of disclosure $\Delta v(h^{\tau_i}; c_i)$
   - Given the values from bidding under h^T and beliefs on evolution of Qs
4. Dist'n of disclosure costs F_Q
   - Compare amount of disclosure under same history h^τ but diff constr costs c
   - Amount of disclosure $\leftrightarrow$ Value of disclosure
5. Value of Entry $V(h^\tau)$
   - Given value fn with/without disclosure and dist'n of disclosure costs F_Q
6. Dist'n of entry timing F_τ and entry costs F_E
   - Compare amount of disclosure at same time τ but with different history h^τ $\Rightarrow$ F_E is identified
     - ⋆ Amount of disclosure $\leftrightarrow$ (Value of Entry, Value of disclosure)
   - Compare amount of disclosure across time $\tau \Rightarrow F_\tau$ is identified

Estimation closely follows the identification argument.

Estimation: parametric assumptions

We assume:

- Firms are *ex-ante* symmetric
- Arrival timing: $F_\tau \sim Beta(\alpha_\tau, \beta_\tau)$
- Entry:
  - With prob. p^E, each firm considers entering the auction
  - When they consider, entry costs: $c^E \sim F_E$

    F_E follows truncated normal on $[0, \infty)$ with parameters μ_E and σ_E
- Disclosure:
  - With prob. p^Q, firm is in need for posting a Q and MUST disclose without any cost.
  - If not, firm can pay cost $c^Q \sim F_Q$ and disclose:

    F_Q follows truncated normal on $[0, \infty)$ with parameters μ_Q and σ_Q

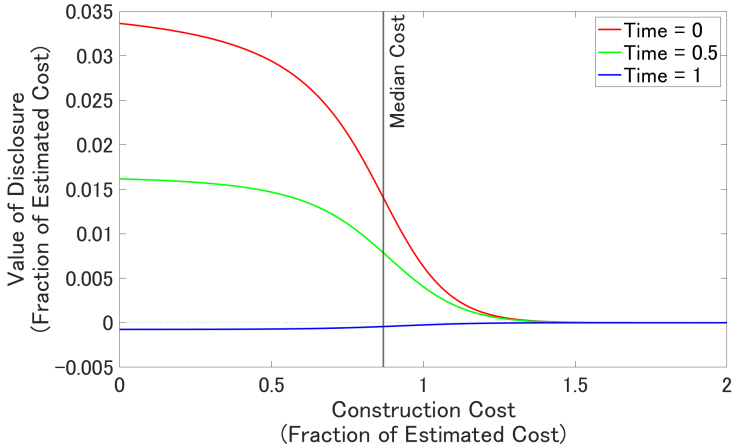
▸ Detail

Outline

Value of Disclosure: Who discloses? Timing matters?

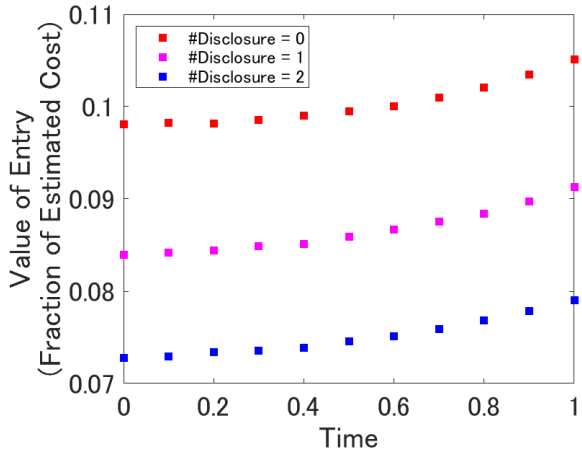
- **Stronger** bidders tend to have **higher** values of disclosure
  - Bidders with 25%-tile cost has 3 times larger value than bidders with 75%-tile cost at $t = 0$
- **Last minute** disclosure has **negative** value

▸ Estimates



Value of Entry

- If we fix the #disclosures available, value of entry ↑ over time
- With more disclosures, value of entry ↓ (Entry prob: 4-6% ↓)



Early Mover Advantage

Suppose you only know arrival timing τ_i, but nothing else

- Expected profit **decreases** over time τ_i
- Firm i with $\tau_i = 0$ has **7.3% higher** expected profit than firm j with $\tau_j = 1$

Intuition:

Gains from deterrence when arrive early $>$ More information from late arrival

Outline

Counterfactuals

We run **counterfactuals** to:

Study the impact of entry disclosure device on auction outcomes

- Entry disclosure has impacts through two channels:
  1. Entry value $\downarrow$ and deter entry from others
  2. Additional information at the bidding stage

Counterfactuals: Scenarios

We compare outcomes from three scenarios:

Counterfactual	Description	Entry Deterrence	Additional Info at Bid
(0) Shutdown	Q&A never becomes public		
(1) Last minute disclosure	Q&A revealed publicly at $t = 1$ No info provided during $t \in [0, 1)$		✓
(2) Status quo	Current Q&A forum	✓	✓

We measure:

- Auctioneer's payment; Winner's construction cost; #Entrants; Total entry cost

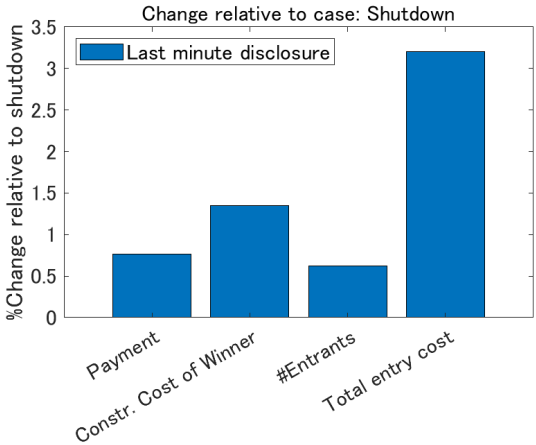
Shutdown → Last minute disclosure

No deterrence effect:

- Some still disclose from exog. reasons
- No costly disclosure
  ⇒ No additional info on constr. costs
- Info only on entry does not (essentially) affect payment (McAfee & McMillan 1987)

Firms are in asymmetric positions when bid:
Disclosed vs. Not disclosed
⇒ Inefficient winners: winner's cost ↑
⇒ payment slightly changes (↑)

Expected profit from entry ↑ ⇒ Entry ↑



Shutdown → Last minute disclosure → Status quo

Possibility of deterrence

- Costly disclosure
  ⇒ additional info on constr. costs

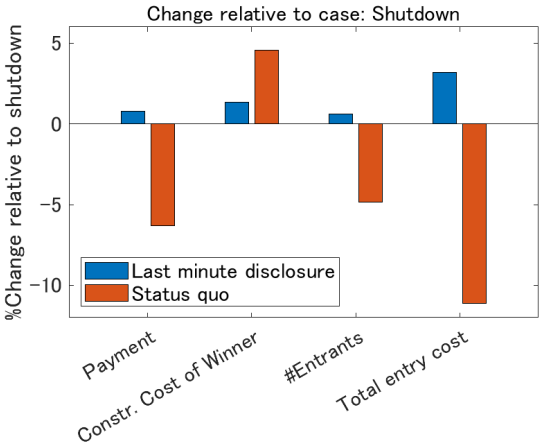
Firms who disclose:

- Giving up info rents
  based on entry info + **constr. costs**

Coordination on entry:

- Entry prob↑ if small #disclosures
  ⇒ #Auctions w/ small #entrants ↓

▸ #Entrants



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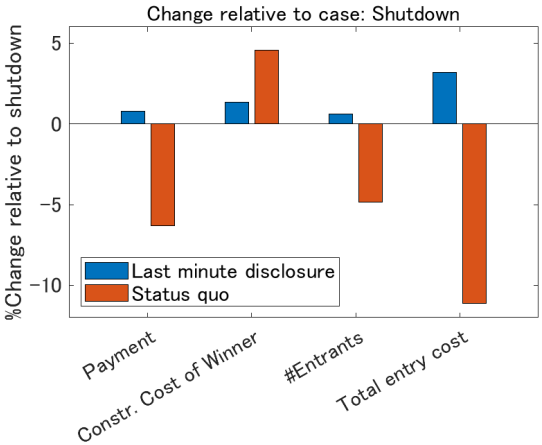
Overall effect on payment:
Coordination on entry push ↓↓ + Info rent ↓↓
> Less entrants push ↑

Stronger asymmetry among firms when bid
⇒ Efficiency loss: winner's cost ↑↑

Expected profit from entry ↓↓ ⇒ Entry ↓↓

▸ #Entrants



Concluding remarks

1. The option to disclose entry and deter entry has a sizable impact on auction outcomes
   - $+$ Auctioneers' payment $\downarrow$ (6.3%) and entry cost $\downarrow$ (11.1%)
   - $-$ Winner's cost $\uparrow$ (4.5%)

2. Information during the entry period must be carefully handled
   - Information about entry
   - Information about strength of agents

Asymmetry in Beliefs

Suppose that there are two firms X and Y. Both enter into the auction.

Consider a case where X *discloses* and Y *does not disclose*.

- Y employs a more aggressive bidding strategy than X
- Y may win the auction even when Y has higher costs than X

  $\Rightarrow$ Inefficient winner

Back

Alternative stories: Q reduces uncertainty

Suppose that disclosure has **no** deterrence effect

Questions reduce uncertainty in the costs

- entry cost: will be incorporated in the model
- construction cost:
  - If posting Q reduces your own cost w/o spillovers,
    $\Rightarrow$ *No* effect on others' bids
    $\Rightarrow$ We see changes in others' bids
  - If your Q reduces others' costs,
    $\Rightarrow$ *Positive* correlation btw posting Q and strength of opponents' best bid
    $\Rightarrow$ We see *Negative* correlation

Back1 Back2 Back3

Alternative stories: Unobs. heterogeneity in uncertainty

Suppose that disclosure has **no** deterrence effect/inviting in more aggressive bids

Unobs. heterogeneity in level of uncertainty across auctions:

If #Qs act as a "good" proxy for quality of the government proposal,

- *Negative* corr. btw #Qs and the strength of bids, across auctions⇒ We see *positive* corr.
- Having one more Q is related with a decrease in bid by 2.5%* of estim. cost
- Having one more Q is related with a decrease in bid by 3.8%* of estim. cost, within firm

Back1 Back2 Back3 More on unobs. heterogeneity

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Unobs. heterogeneity in level of uncertainty across auctions + Q reduces constr. costs

- Correlation above suggests that the latter effect dominates $\cdots(*)$
- Compare bid from:
  - (i) Firms who posts a Q vs. (ii) Firms who does not
  - (i) places a weaker bid ⇒ This goes against $(*)$

Back1 Back2 Back3

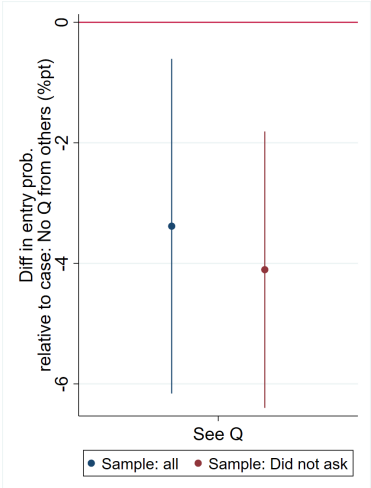
Correlation: Seeing Q and entry probability (additional)

If disclosure deters others' entry

- *Negative* correlation btw Q being posted from others and entry prob.

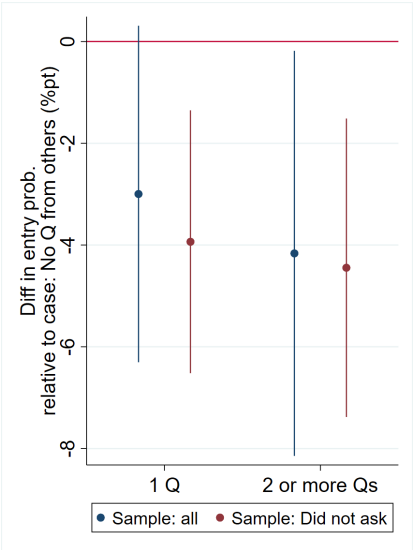
Entry prob. of firm who see Qs is **lower**:

- than those who see none by 14% (3.4pp)



Back1 Back2 Back3

Entry prob. and Seeing Q



Back1 Back2 Back3

Parameter estimates: primitives

	Estimate	S.E.
Entry		
Prob. of considering entry: p^E		
Const.	0.851	0.146
$\ln(\#$ Pot bidder)	-0.231	0.093
μ_E	-2.926	0.120
σ_E	0.383	0.182
Disclosure		
Prob. of Always Disclose: p^Q	0.268	0.139
μ_Q	-2.416	0.501
σ_Q	0.642	1.102
Entry Timing		
α_τ	1.227	0.314
β_τ	0.661	0.227

▸ Entry Timing ▸ Entry Prob. ▸ Disclosure Prob.

Primitives of the model

Primitives of the model are the following:

- Dist'n of entry timing: $\tau_i \sim F_\tau$
- Dist'n of entry cost: $c_i^E \sim F_E$
- Dist'n of question cost: $c_i^Q \sim F_Q$
  - We allow this to be positive or negative
- Dist'n of construction cost: $c_i \sim F_c$

We assume that draws are iid, and these 4 objects are mutually independent.

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Parameter estimates: Opponents' best bid

We assume that opponents' best bid follows log-normal:

Variables	Estimate	S.E.
μ		
Disclosed	0.044*	0.027
Disclosed $\times\tau$	-0.045	0.033
#Discl. from others	-0.037*	0.010
Auction-level characteristics	Yes	
$\log\sigma$		
# Discl. from others	-0.207*	0.039
Auction-level characteristics	Yes	

*: $p < 0.1$

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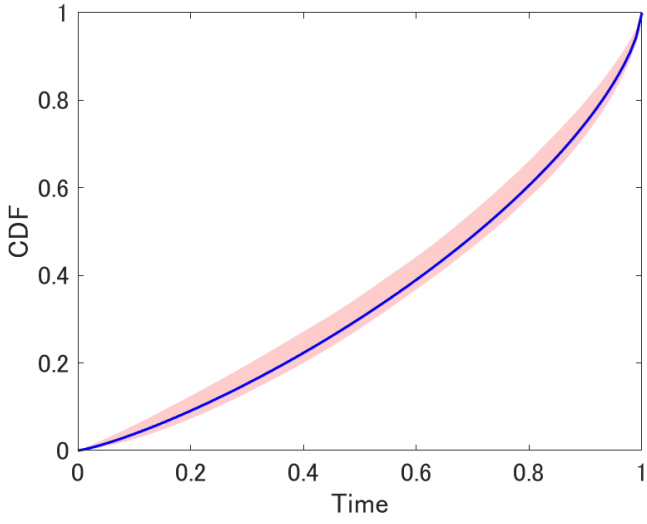
Entry timing



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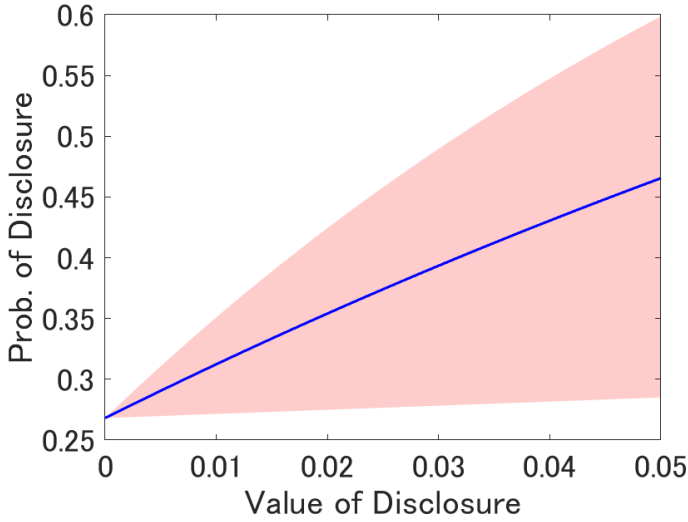
Probability of disclosure



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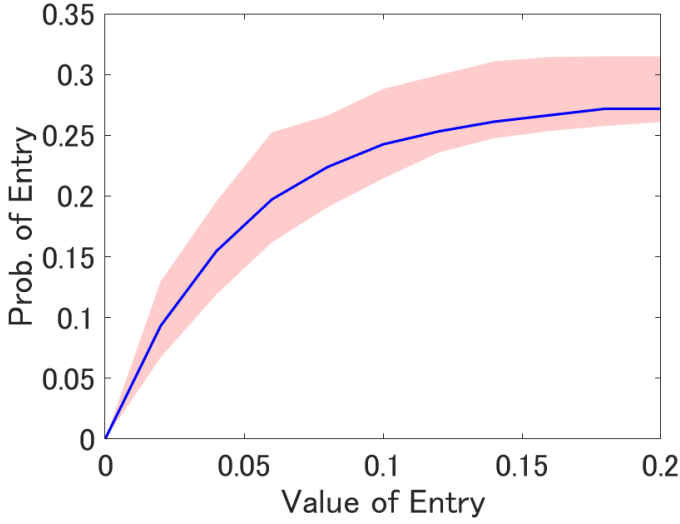
Probability of Entry



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Model

We consider a two-stage model:

- First stage: Entry and Disclosure
  - Firms sequentially arrive
  - Observes the disclosure history up to their arrival time
  - Decide enter/ not enter
  - Upon entry, decide disclose or not

- Second stage: Bid
  - Firms place bids after the first stage period ends
  - Given the entire disclosure history, entrants bid

Model: First-stage – Entry and Disclosure

- N risk neutral firms who are potential entrants
- Each firm draws entry timing $\tau_i \in [0, T] \qquad (T = 1)$
- Firm i makes decisions at τ_i in the following order:
  1. Observe disclosure history h^{τ_i}
  2. Draws entry cost c_i^E and makes entry decision $a_i^E \in \{0, 1\}$
  3. If they enter, they observe disclosure cost c_i^Q and construction cost c_i
     - ⋆ Disclosure c_i^Q may be positive OR negative
  4. Make decision on disclosure $a_i^Q \in \{0, 1\}$
     - ⋆ If they disclose, it becomes public at τ_i, and disclosure history gets updated

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Estimation

Estimation closely follows the identification argument

1. Using bidding data and disclosure history at T:
   - Estimate costs c_i
2. Using the observed evolution of disclosure histories:
   - Estimate beliefs $\Pr^i(h^T|h^\tau, \tau_i = \tau, a_i^Q)$
3. Given the estimated objects:
   - Estimate value function $v(h^\tau; c_i, A_i^Q)$ and value of disclosure $\Delta v(h^{\tau_i}; c_i)$
4. Using the entire data:
   - Estimate F_τ, F_Q, F_E via maximum likelihood

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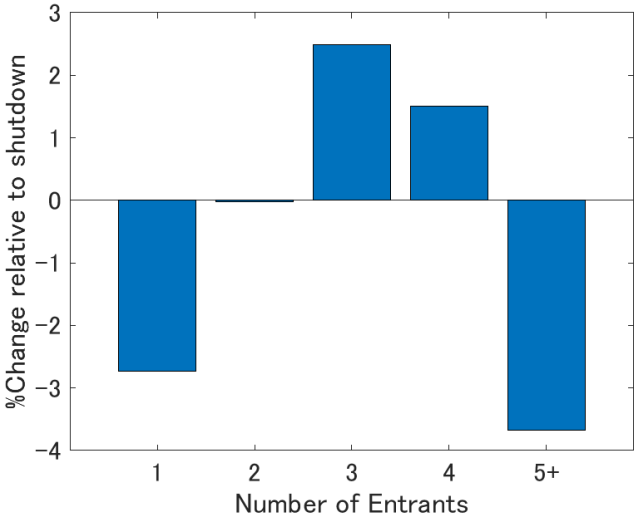
Counterfactual – Status Quo



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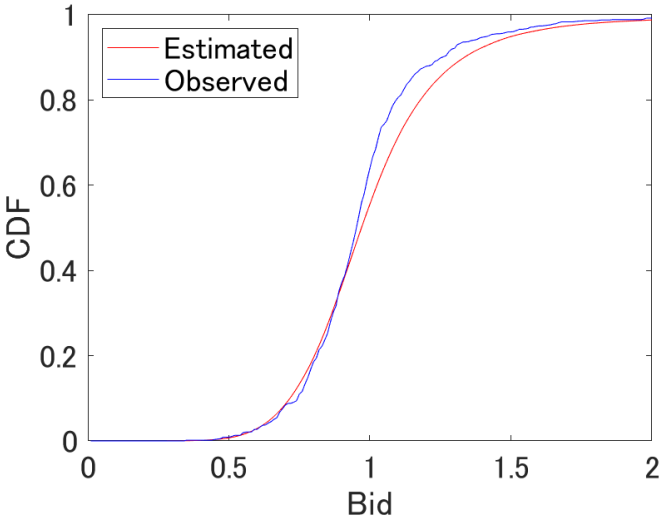
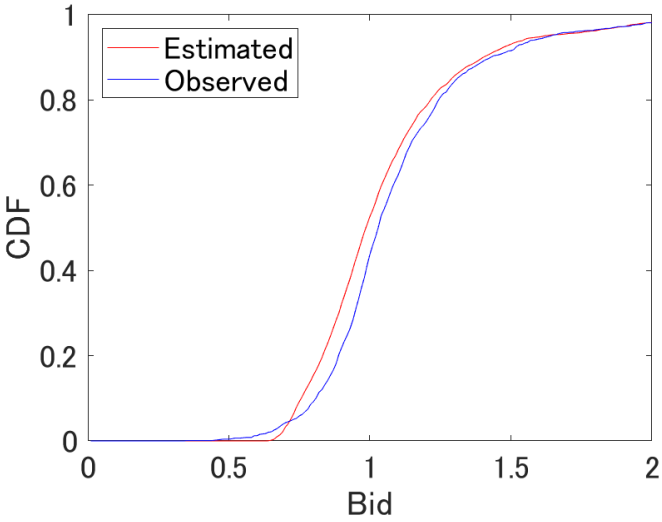
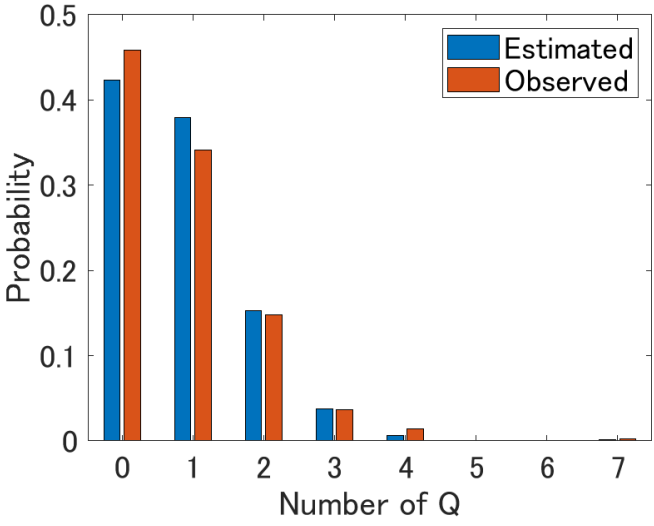
Model Fit: Opponent's best bid



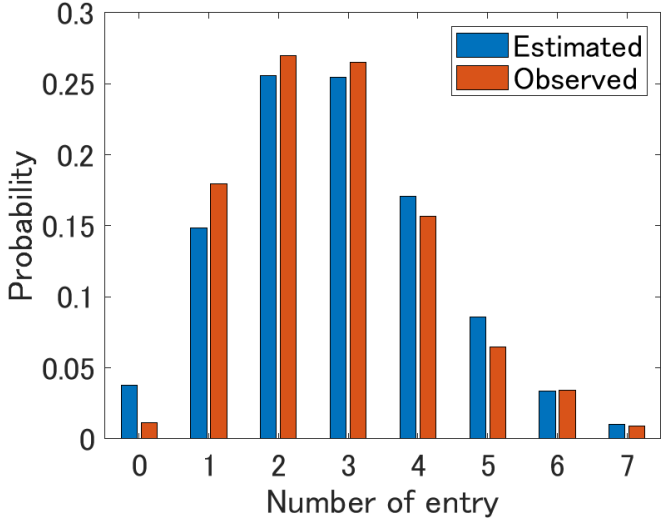
Model Fit: Bid



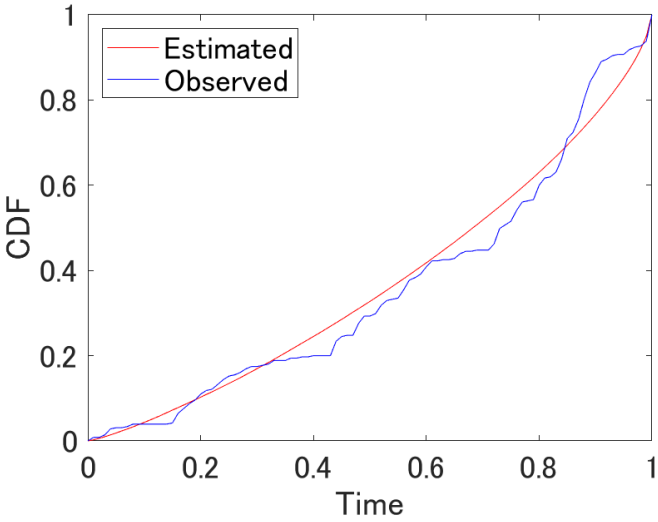
Model Fit: Number of Qs



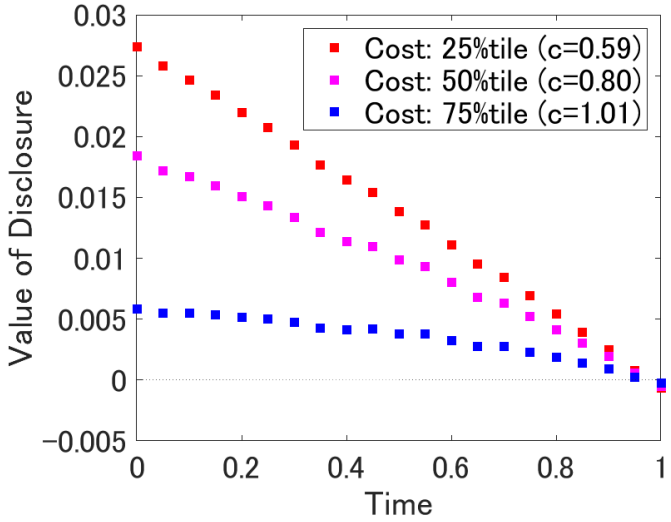
Model Fit: Number of Entrants



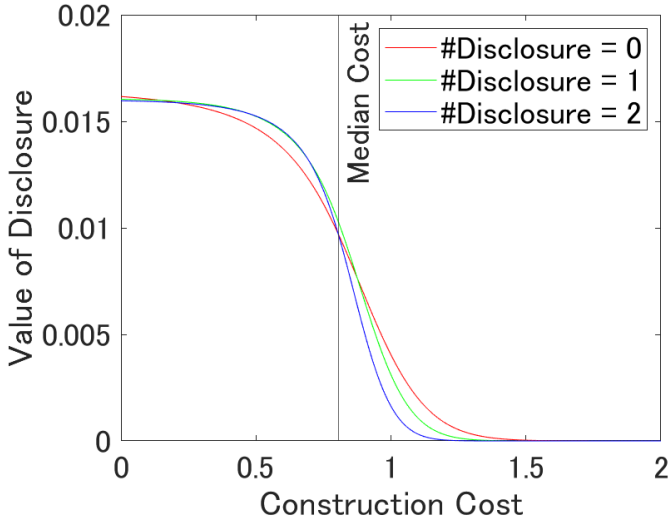
Model Fit: Disclosure Timing



Value of Disclosure: Change over Time



Value of Disclosure: by Question History



What can the auctioneer do?: Optimal signal

Suppose that the auctioneer:

- knows firms' entry status
- send a private signal to bidders, conditional on the number of entrants
- can commit to how this signal is created

The optimal signal (Bergemann & Morris (2019)):

- Send a bid schedule to each entrant (a map from constr costs to bids)
- Design a joint distribution of tuples of bid schedules
- Designed with *"Obedience constraint"*
  - Optimal for the entrants to follow the bid schedule they received