Evaluating Discretion in Government Procurement

Karam Kang and Robert A. Miller

Carnegie Mellon University

November 2017

Competition in Government Procurement

- US Federal regulations allow restricting entry and negotiations
  - Reforms in the Clinton administration to allow more discretion
  - In FY 2010, $241 billion (45%) paid for contracts with a single bid
- More competition is costly
  - Sellers (Contractors): Bid preparation
  - Buyer (Procuring agency): Administration, capture, corruption
- Quantify factors determining competition and the value of discretion
  - Develop, identify, and estimate a procurement model
  - Employ data on the IT service contracts of FY 2004-2012

What This Paper Does

- Integrate two important institutional features:
  1. Buyer chooses the extent of competition
  2. Final contract price is often different from initial price
- Competition affects the terms of initial contract and the final price
- Important to study the mechanism through which ex-post price changes occur in conjunction with the buyer's discretion regarding the extent of competition

Key Institutional Feature 1: Endogenous Competition

- Regulations permit contracting without full and open competition
  1. Non-discretionary: Statutes, international agreements, set-asides
  2. Discretionary: Patents, copyrights, urgency
- Most studies estimate effects of limited competition, *taking policies given* (Krasnokutskaya & Seim, 2011; Athey, Coey & Levin, 2013)
- We study endogenous competition, focusing on **buyer preferences**
  - Related to empirical studies on government buyer behaviors (Bandeira, Prat & Valletti, 2009; Coviello, Guglielmo & Spagnolo, 2017)

Key Institutional Feature 2: Ex-post Price Changes

- Ex-post changes may arise from
  1. Contingencies specified in the original contract
  2. Ex-post renegotiations
- Ex-post renegotiations and their costs empirically studied (Gagnepain, Ivaldi & Martimort, 2013; Bajari, Houghton & Tadelis, 2014)
- Contingencies received scant attention in the empirical literature
- We fill this gap by exploiting the data specifying each contract change
  - *Unilateral*: Following the original contract
  - *Bilateral*: Renegotiation, requiring both parties' agreement

Literature Review

- Corruption and regulatory capture in procurement:
  - Bandiera, Prat & Valletti (2009); Coviello, Guglielmo & Spagnolo (2014)
- Ex-post renegotiations:
  - Crocker & Reynolds (1993); Bajari & Tadelis (2001); Gagnepain, Ivaldi & Martimort (2013); Bajari, Houghton & Tadelis (2014)
- Auctioning incentive contracts:
  - Laffont & Tirole (1987), McAfee & McMillan (1987), Riordan & Sappington (1987)
- Identification of principal-agent models:
  - Perrigne & Vuong (2011), Gayle & Miller (2015)

Data

- Source: Federal Procurement Data System - Next Generation
- IT/telecommunications service contracts of FY 2004-2012:
  1. IT strategy & architecture, programming, cyber security, data entry, backup, broadcasting, storage, and distribution, etc.
  2. With specified quantity and delivery schedule
  3. Large ($300K–$5M), long ($\geq$ 30 days), and commercially unavailable
  4. Noncompeted for discretionary reasons
  5. Total of $3.2 billion (in 2010 dollars), 2,203 contracts

Competition for IT Service contracts

Extent of competition	Obs.	Size ($M)		One Bid	Num. Bids	
		Mean	SD	Ratio	Mean	Median
No/limited competition	1,631	1.49	1.20	0.93	1.39	1
Unavailable for competition	796	1.67	1.19	0.98	1.06	1
Set-aside for small business	183	1.71	1.31	0.44	4.20	2
Not competed by discretion	652	1.20	1.12	1.00	1.00	1
Full and open competition	572	1.30	1.10	0.36	4.08	2
Sealed bids	12	2.14	1.22	0.67	1.58	1
Competitive proposals	310	1.38	1.16	0.27	4.55	3
Simplified acquisition	185	1.01	0.84	0.48	2.22	2
Other competitive procedures	65	1.61	1.21	0.37	7.58	2
Total	2,203	1.44	1.17	0.78	2.09	1

Data Feature 1: Competition and Price

1. Contracts awarded by military agencies (Departments of Defense, State, and Homeland Security) tend to be less competitive
2. More competition is associated with higher contract price, even after controlling for observed heterogeneity of each contract
   - Consistent with endogenous determination of number of bids where buyer takes into *the distribution of seller costs* and *buyer costs of intensifying competition* (both not part of the data)

Data Feature 1: Competition and Price (Cont'd)

	Noncompetitive	One Bid	Log (Total Contract Price)	
	(1)	(2)	(3)	(4)
Military agency	0.130**	0.118***		
	(0.055)	(0.037)		
Competitive			0.238**	0.038
			(0.094)	(0.089)
Log (Numer of bids)				0.199***
				(0.059)
Various FEs†	Yes	Yes	Yes	Yes
N	962	962	962	962
R^2	0.171	0.168	0.317	0.327

Note: The standard errors, in parentheses, are clustered at the 4-digit product and service code level, and provided in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. † product and service codes, location of the contract performance (state), year of award, and month of the award, respectively. Agency fixed effects are included for (3) and (4).

Data Feature 2: Price and Duration Changes

1. Price changes are frequent and considerable in size
2. Price changes and delays are positively correlated
3. Price changes occur regardless of contract type as stated in the data
   - Firm-fixed price contracts supposedly make the seller fully responsible for the performance costs and resulting profit or less (FAR 16)
   - Firm-fixed price contract does not seem to be a commitment by the buyer on price changes
4. However, firm-fixed price contracts have less price changes associated with administrative actions, even after controlling for observed contract attributes

Data Feature 2: Price and Duration Changes (Cont'd)

	Price				Duration		Corr.‡
	All		Firm-Fixed†		All		
	Amount	Freq.	Amount	Freq.	Days	Freq.	
Base	712.2		690.9		433.4		
Final	1,256.6		1,112.7		787.1		
Change							
Any	543.6	0.69	421.5	0.64	353.7	0.57	0.41
Added work	23.1	0.07	16.9	0.08	10.4	0.04	0.44
Change order	41.0	0.13	37.1	0.11	21.5	0.09	0.35
Supplemental	52.0	0.19	37.0	0.18	33.2	0.16	0.31
Use options	211.6	0.30	169.7	0.28	141.1	0.26	0.42
Administrative	215.8	0.52	160.8	0.47	147.5	0.38	0.29

Note: Unconditional average price (in 1,000 dollars, CPI-adjusted to 2010) and duration are shown and standard deviations are in parentheses. All contracts in the final sample (962 obs) are included. † Firm-fixed price contracts (653 obs).

Data Feature 2: Price and Duration Changes (Cont'd)

	Added Work	Change Order	Supp. Agmt.	Options	Admin.
Firm-fixed price contract	-1.649	8.685	-33.21	-52.59	-181.7***
	(11.68)	(16.05)	(20.30)	(41.52)	(47.60)
Fixed effects†	Yes	Yes	Yes	Yes	Yes
N	962	962	962	962	962
R^2	0.404	0.385	0.281	0.314	0.289

Note: The dependent variables are the amount of price changes in 1,000 dollars (CPI-adjusted to 2010) for each of the six categories of reasons for modification. All contracts in the final sample are included; standard errors are provided in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. † 4-digit product and service codes, procurement agency, location of the contract performance (state), year of award, and month of the award, respectively.

Repeated Interactions?

- Sellers who win multiple contracts do NOT face less competition
- We observe number of losing bids, but not their identities

	Num. Sellers	Num. Contracts	Competed	Num. Bids
Non-repeat sellers	284	284	0.33	2.38
	46.0%	29.5%	(0.03)	(0.54)
Repeat sellers (≤ 10)	282	405	0.28	1.69
	45.6%	42.1%	(0.02)	(0.10)
Repeat sellers (> 10)	52	273	0.37	2.57
	8.4%	28.4%	(0.03)	(0.40)
Total	618	962	0.32	2.14

Notes: We divide the final sample into three categories based on the seller's history of winning any of the definitive IT and telecommunications contracts with a contract size greater than or equal to $300,000 (8,199 contracts in total): *non-repeat sellers*, *repeat sellers* with 2–10 contracts, and those with more than 10.

Buyer's Payoff and Choices

- Final contract price = Base price (p) + Ex-post price change (Δ)
- Buyer's total cost:

$$\underbrace{p + \Delta}_{\textit{Transfer}} + \underbrace{\kappa(n)}_{\textit{Bidding}} + \underbrace{\eta}_{\substack{\textit{Competitive} \\ \textit{solicitation}}}$$

- Buyer decides
  1. Whether to solicit *extra* bids (i.e., permit competition)
  2. Bidder arrival rate λ: Number of *extra* bids $\sim$ *Poisson*(λ)
  3. Menu of contracts and the winner

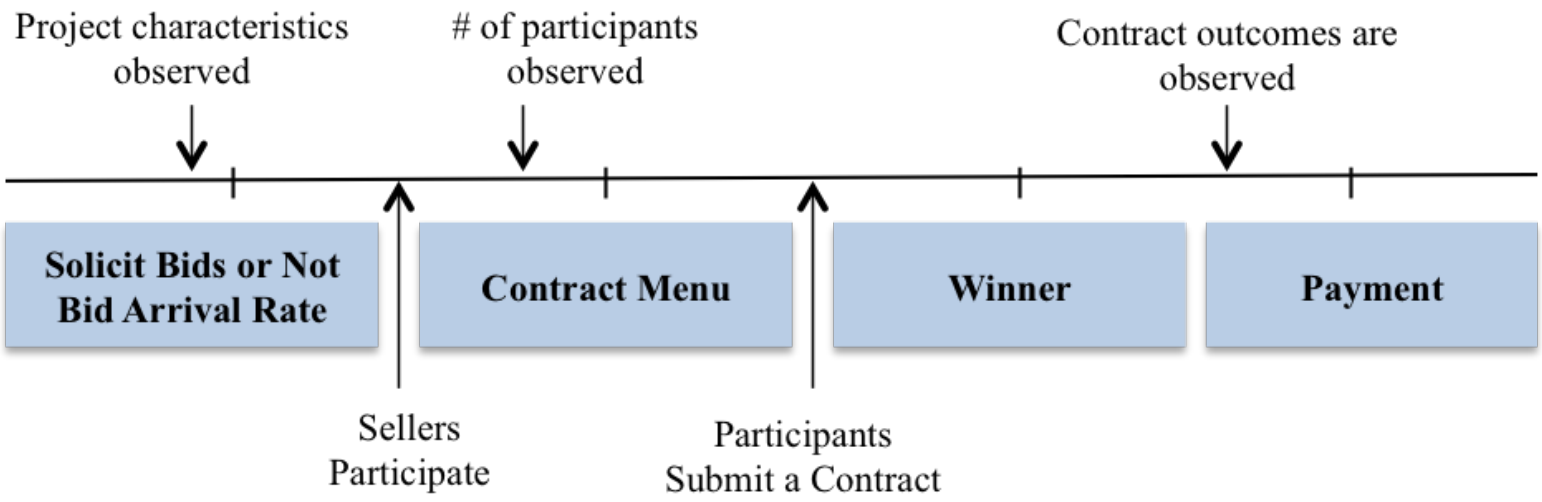
Sellers' Payoff and Choice

- Cost of completing a project:
  1. Deterministic (hidden): Low-cost (α) and high-cost ($\alpha + \beta$)
  2. Stochastic (revealed to both parties): Ex-post cost change (ϵ)
- Payoff from contract (p, Δ) and realized ϵ for a low-cost seller:

$$\underbrace{p - \alpha}_{\textit{deterministic}} + \psi \underbrace{(\Delta - \epsilon)}_{\textit{stochastic}}$$

- Liquidity concerns, or the cost of working capital: $\psi' > 0, \psi'' < 0$, $\psi(0) = 0$, and $\psi'(0) = 1$
- Upon participation, sellers choose a contract from a menu

Timeline



- Project characteristics: Ratio of low-cost sellers (π) and η
- Stochastic contract outcomes: ϵ and s
  1. Uninformative: ϵ is independent of type
  2. Informative: $s \sim \underline{F}(\cdot)$ or $\overline{F}(\cdot)$ on common support, $\underline{F}(s) \neq \overline{F}(s)$ for some s with positive measure

Buyer's Problem (A Cut-down Version)

- Given ex-ante symmetric n sellers, buyer minimizes

$$\underbrace{(1-(1-\pi)^n)}_{\substack{\text{Prob. of having} \\ \text{at least 1 low-cost} \\ \text{seller}}} \quad \underline{p}_n + (1-\pi)^n(\overline{p} + \int q(s)\overline{f}(s)ds)$$

Subject to: $\overline{p} + \int \psi[q(s)]\overline{f}(s)ds - (\alpha+\beta) \geq 0$ (IR: High-cost)

$$\underline{\phi}_n \left\{ \underline{p}_n - \alpha \right\} \geq \overline{\phi}_n \left\{ \overline{p} + \int \psi[q(s)]\underline{f}(s)ds - \alpha \right\} \text{ (IC: Low-cost)}$$

Equilibrium Menu of Contracts

Theorem (4.1, p.15)

The minimal number of items on an optimal menu is two. All optimal menus induce a separating equilibrium amongst the sellers: low-cost sellers submit fixed contracts and high-cost sellers submit variable contracts. The optimal menu containing two items is uniquely defined by the price of the fixed contract:

$$\underline{p}_n = \alpha + \frac{\pi(1-\pi)^{n-1}}{1-(1-\pi)^n}\left(\beta - \int \psi[q(s)]\left[1-l(s)\right]\overline{f}(s)ds\right),$$

and the variable contract:

$$\overline{p} = \alpha + \beta - \int \psi[q(s)]\overline{f}(s)ds,$$

$$q(s) = \begin{cases} h\left(\frac{1-\min\{\pi,\tilde{\pi}\}}{1-\min\{\pi,\tilde{\pi}\}l(s)}\right) & \text{if } l(s) \leq \tilde{l}(\min\{\pi,\tilde{\pi}\}), \\ M & \text{if } l(s) > \tilde{l}(\min\{\pi,\tilde{\pi}\}). \end{cases}$$

Equilibrium

1. Given a number of bids, the optimal menu of two contracts and the winner selection rule:
   - All optimal menus induce a separating BNE: Low-cost sellers for fixed contracts; High-cost sellers for variable ones; Fixed contracts preferred
   - Optimal menu containing two items is *uniquely* defined
2. If soliciting bids, choose the effort to attract bids (λ) to minimize

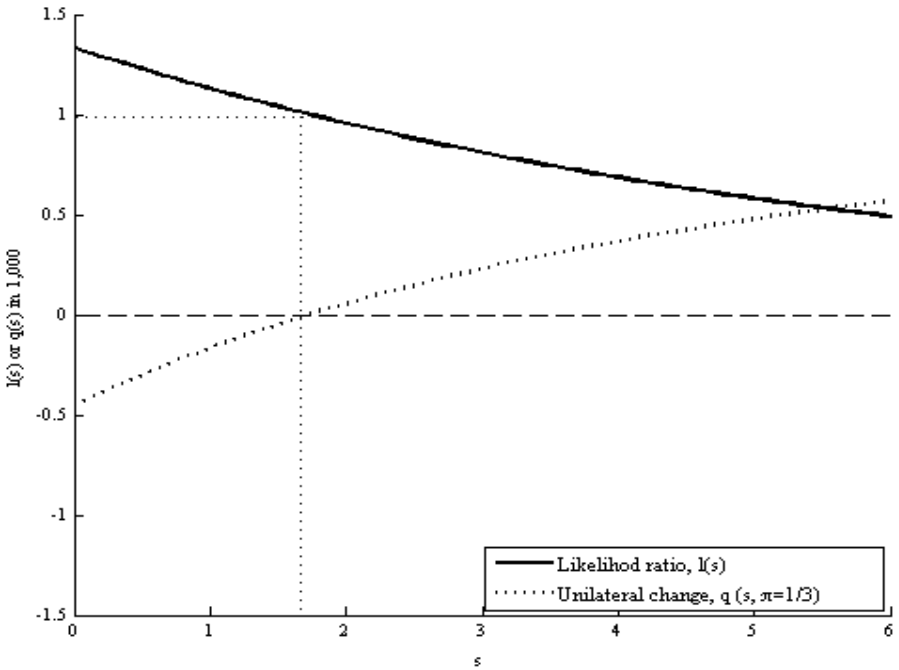
$$U(\lambda, \eta) = \sum_{j=0}^{\infty} \frac{\lambda^j e^{-\lambda}}{j!} \left[T(j+1) + \kappa(j+1) \right] + \eta$$

3. Solicit bids if and only if $U(\lambda^*, \eta) \leq U(0, 0)$

Characterization of the Menu: Variable Contract

$$\textit{Base price}: \quad \overline{p} = \alpha + \beta - \int \psi[q(s)]\overline{f}(s)ds$$

$$\textit{Unilateral change}: \quad \psi'[q(s)]\left[1 - \pi \underline{f}(s)/\overline{f}(s)\right] = 1 - \pi$$



- Low-cost ($\alpha = 1000$)
- High-cost ($\alpha + \beta = 1500$)
- Ratio of the low-cost type: $\pi = 1/3$
- Outcome s dist: $\underline{F}(\cdot) \sim \textit{Gamma}(1, 1.5)$, $\overline{F}(\cdot) \sim \textit{Gamma}(1, 2)$

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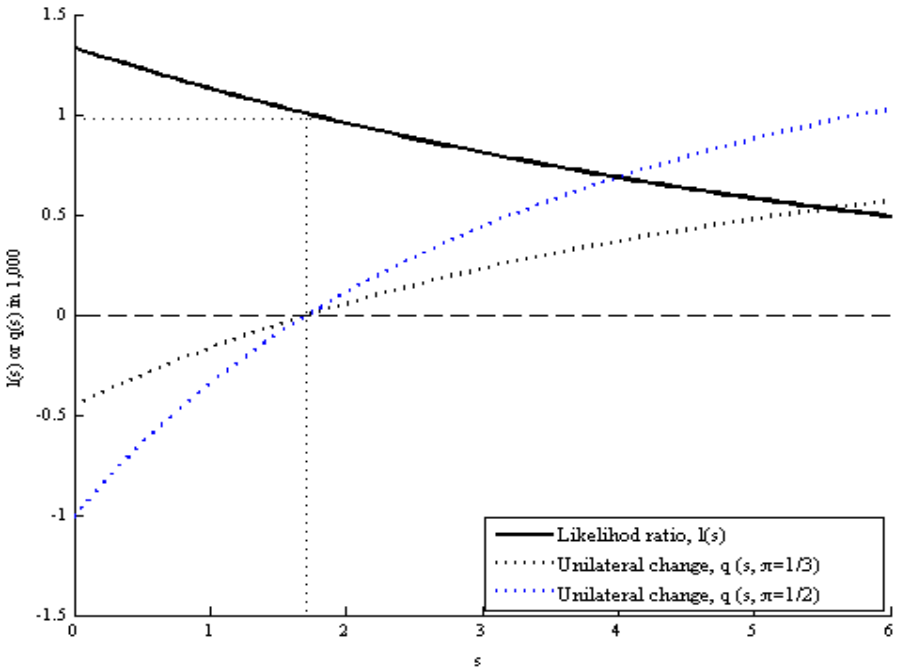

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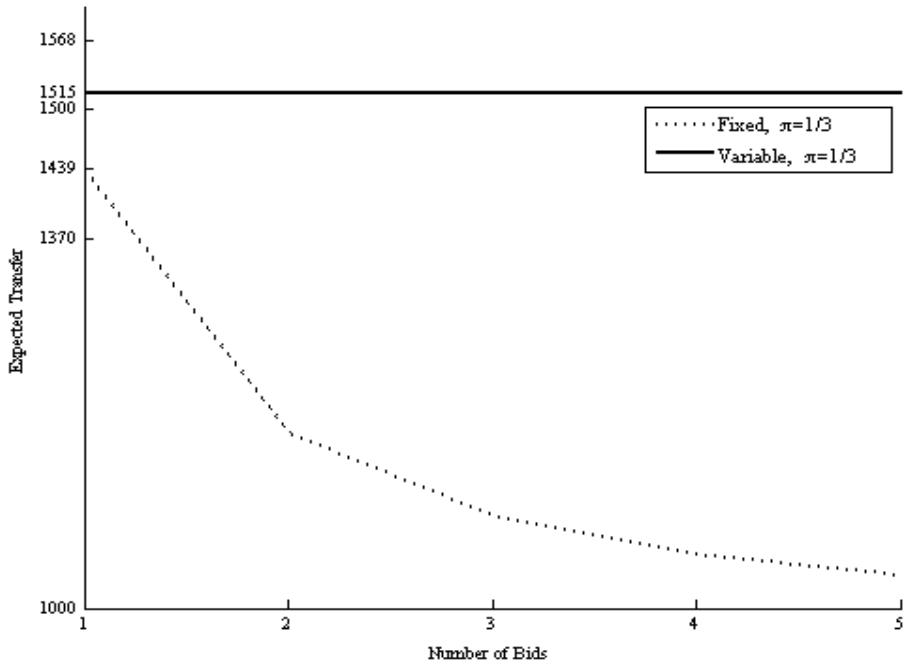
Characterization of the Menu: Expected Transfer

$$\textit{Fixed}: \quad \underline{p}_n = \alpha + \frac{\pi(1-\pi)^{n-1}}{1-(1-\pi)^n}\left\{\beta - \int \psi[q(s)]\left[\overline{f}(s) - \underline{f}(s)\right] ds\right\}$$

$$\textit{Variable}: \quad \overline{p} + \int q(s)\overline{f}(s)ds = \alpha + \beta + \int \{q(s) - \psi[q(s)]\}\,\overline{f}(s)ds$$



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Characterization of the Menu: Expected Transfer

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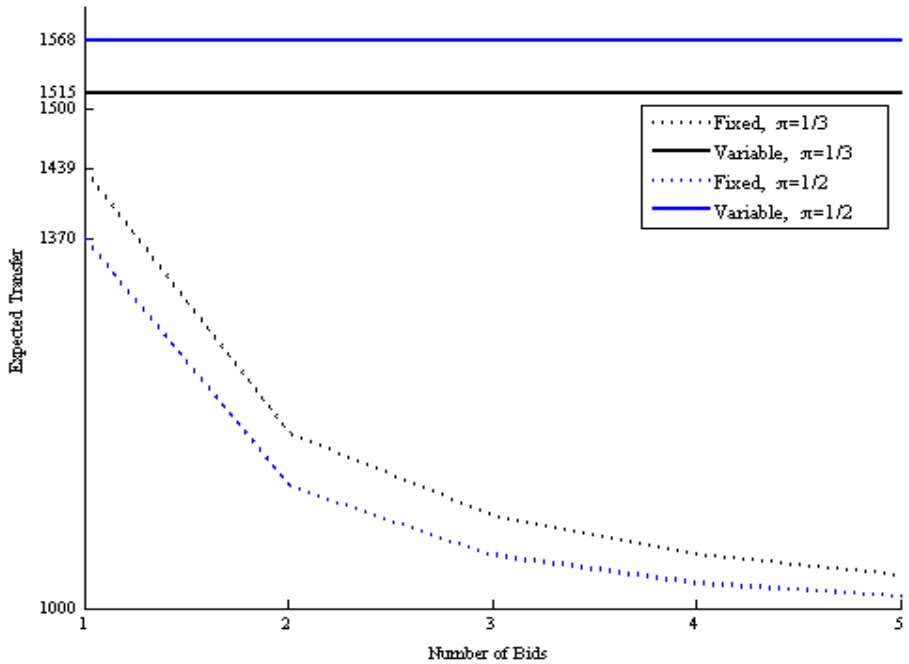
$$\textit{Variable}: \quad \overline{p} + \int q(s)\overline{f}(s)ds = \alpha + \beta + \int \{q(s) - \psi[q(s)]\}\,\overline{f}(s)ds$$



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Identification

- Observe the joint distribution of (solicitation, number of bids, contract type, base price, ex-post price changes, and contract outcomes)
- π as a project-specific unobserved heterogeneity
  - More competition, higher price conditional on project attributes
  - We assume that (π, s, ϵ, η) are mutually independent
- Allow project costs and bidding costs to vary with π
- We identify (i) the distribution of (π, s, ϵ, η); (ii) project costs and bidding costs as functions of π; and (iii) liquidity cost function

Identification of Seller Primitives

Lemma (5.2, p.21)

$f_{\pi|c,n,v}(\pi|c,n,v)$ *is identified.*

Theorem (5.1, p.21)

$\psi(q)$, $\alpha(\pi)$ *and* $\beta(\pi)$ *are identified, and for* $n \in \{2,3,\ldots\}$*:*

$$\begin{aligned}
\alpha(\pi) &= \frac{1-(1-\pi)^n}{1-(1-\pi)^{n-1}}\underline{p}_n^*(\pi,c) - \frac{\pi(1-\pi)^{n-1}}{1-(1-\pi)^{n-1}}\underline{p}_1^*(\pi,c), \\
\beta(\pi) &= \overline{p}(\pi) + \int \psi\left(h\left[\frac{1-\pi}{1-\pi l(t)}\right]\right)\overline{f}(t)\,dt - \alpha(\pi).
\end{aligned}$$

Sketch of the Proof for Identification of Seller Primitives

- Lemma 5.1: monotone relationships in π (ratio of low-cost sellers)
  1. Higher π, more volatile ex-post price changes ($\partial \left| q(s;\pi) \right| / \partial \pi > 0$)
  2. Higher π, lower fixed price values ($\partial \underline{p}_n(\pi) / \partial \pi < 0$)
  3. Higher π, lower initial price for variable contracts ($\partial \overline{p}(\pi) / \partial \pi < 0$)
- Equilibrium of the model is separating: Seller type is observed by contract type (low-cost= fixed; high-cost =variable)
- With these two equilibrium restrictions, we nonparametrically identify (i) liquidity cost function, (ii) the distribution of π conditional on contract type, number of bids, and solicitation, and (iii) project costs.

Identification of Seller Primitives (1/4)

- Given the separating equilibrium, the distribution of s for fixed contracts is $\underline{f}(s)$, and that of variable ones is $\overline{f}(s)$ (and hence $l(s) \equiv \underline{f}(s)/\overline{f}(s)$ is identified)
- We start with the FOC wrt q:

$$\psi'[q(s)]\,[1 - \pi l(s)] = 1 - \pi$$

- The following first-order ODE is derived from the above FOC

$$\psi''(q) = \left[\frac{1 - \psi'(q)}{1 - l^*(q, \overline{p})}\right] \psi'(q) \frac{\partial l^*(q, \overline{p})}{\partial q}$$

  where $l^*(\overline{p}, q)$ is $l(s)$ for the corresponding $(\overline{p}, q)$

- We can solve $\psi(\cdot)$ uniquely using $\psi'(0) = 1$ and $\psi(0) = 0$

Identification of Seller Primitives (2/4)

- π corresponding to each variable contract $(\overline{p}, q, s)$ is identified from the FOC by:

$$\pi_{q,s} \equiv \frac{1 - \psi'\left[q(s)\right]}{1 - \psi'\left[q(s)\right] l(s)}$$

  - Identify π distribution for variable contracts: $f_{\pi|c,n,v}(\cdot|c, n, 1)$

- Using the theoretical prediction on the probability of having a fixed-contract conditional on (π, n):

$$f_{\pi|c,n,v}(\pi|c, n, 0) = \frac{\left[1 - (1-\pi)^n\right] \Pr(v = 1|c, n)}{(1-\pi)^n \Pr(v = 0|c, n)} f_{\pi|c,n,v}(\pi|c, n, 1)$$

Identification of Seller Primitives (3/4)

- Joint probability that a contract is fixed and $\pi \leq \pi^*$:

$$\begin{aligned}\Pr\{\pi \leq \pi^*, v = 0 \,|n\} &= F_{\pi|v,n}(\pi^* \,|0, n)\Pr(v = 0 \,|n) \\ &= \int_{\pi=\underline{\pi}}^{\pi^*} f_{\pi|n}(\pi \,|n)\left[1-(1-\pi)^n\right] d\pi.\end{aligned}$$

- By taking the first order derivative with respect to π^*:

$$f_{\pi|v,n}(\pi^* \,|0, n)\Pr(v = 0 \,|n) = f_{\pi|n}(\pi^*|n)\left[1-(1-\pi^*)^n\right].$$

- Note that

$$\Pr(v = 1|\pi^*, n) = (1-\pi^*)^n = \frac{f_{\pi|v,n}(\pi^*|1, n)\Pr(v = 1|n)}{f_{\pi|n}(\pi^*|n)}$$

Identification of Seller Primitives (4/4)

- Using the monotonicity between the fixed-price ($\underline{p}_n$) and π:

$$\underline{p}_n^*(\pi, c) = G_{\underline{p}_n|c}^{-1}\left(\int_{\pi}^{\pi_{\max}} f_{\pi|c,n,v}(x\,|c, n, 0)\,dx \middle| c\right).$$

- Project costs are identified from the IR and IC conditions:

$$\alpha(\pi) = \frac{1-(1-\pi)^n}{1-(1-\pi)^{n-1}}\underline{p}_n^*(\pi, c) - \frac{\pi(1-\pi)^{n-1}}{1-(1-\pi)^{n-1}}\underline{p}_1^*(\pi, c)$$

$$\beta(\pi) = \overline{p}^*\left(h\left[\frac{1-\pi}{1-\pi l(s)}\right], s\right) + \int \psi\left(h\left[\frac{1-\pi}{1-\pi l(t)}\right]\right)\overline{f}(t)\,dt - \alpha(\pi)$$

where $\overline{p}^*(q, s)$ is identified directly from data

Sketch of the Proof for Identification of Buyer Primitives

- Recall buyer's total cost:

$$\underbrace{p + \Delta}_{\textit{Transfer}} + \underbrace{\kappa(n)}_{\textit{Bidding}} + \underbrace{\eta}_{\substack{\textit{Competitive} \\ \textit{solicitation}}}$$

- Transfer and *the distribution of π conditional on n and solicitation* have been identified from the seller primitives
- Bidding costs are partially identified from the FOC regarding the extra bid arrival rate, $\lambda(\pi)$
- Exploiting variation in π, assumed to be exogenous to the cost of competitive solicitation (η), probability of solicitation conditional on π help partially identify the distribution of η

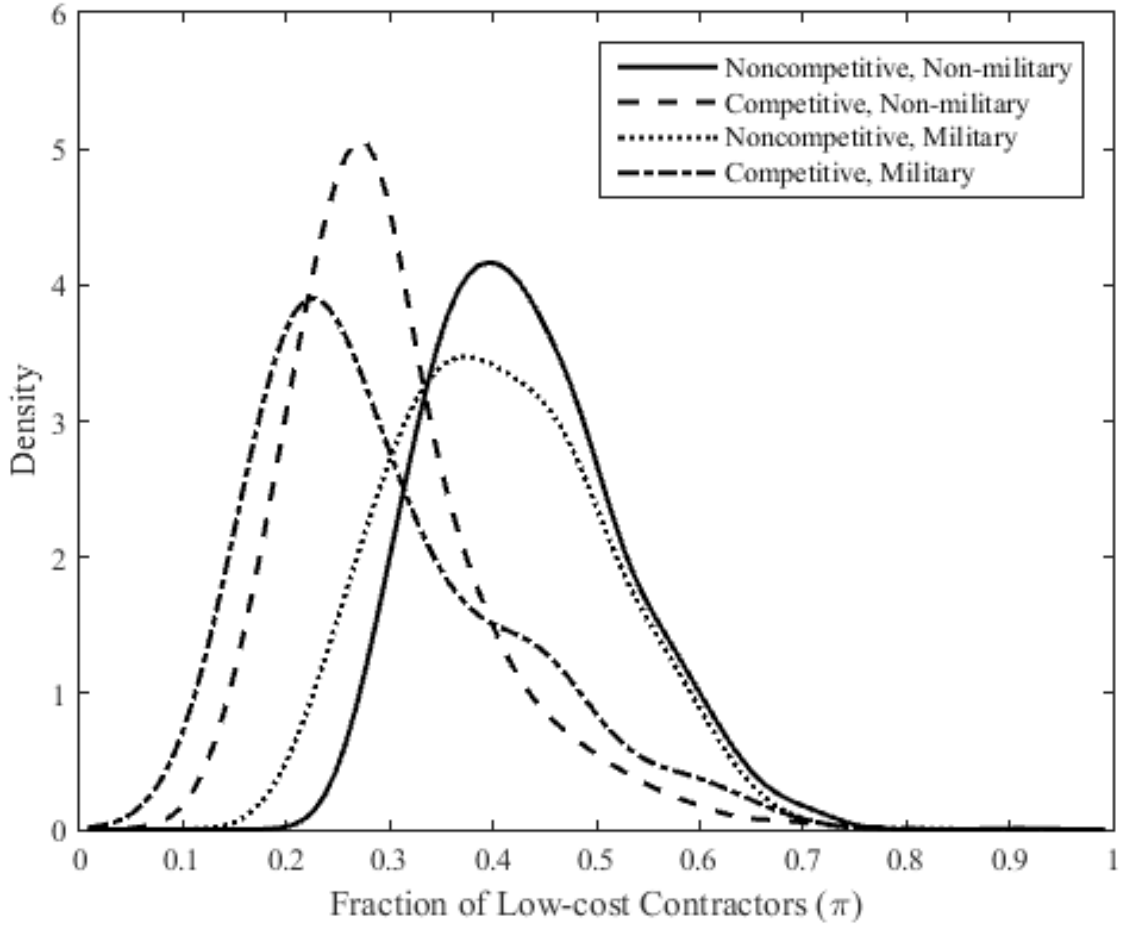
Estimation

- We estimate a parametric model using a simulated GMM estimator
- Estimated cost components for median contracts:

	Non-military		Military	
(in $K)	Estimate	SE	Estimate	SE
Project cost for low-cost sellers	884.1	40.4	910.8	45.8
Project cost difference	271.3	32.1	235.3	32.1
Ex-post cost changes	139.1	15.8	265.2	36.7
Bidding cost with two bidders	52.1	8.9	52.1	8.9
Cost of competitive solicitation	20.5	4.8	33.6	7.6

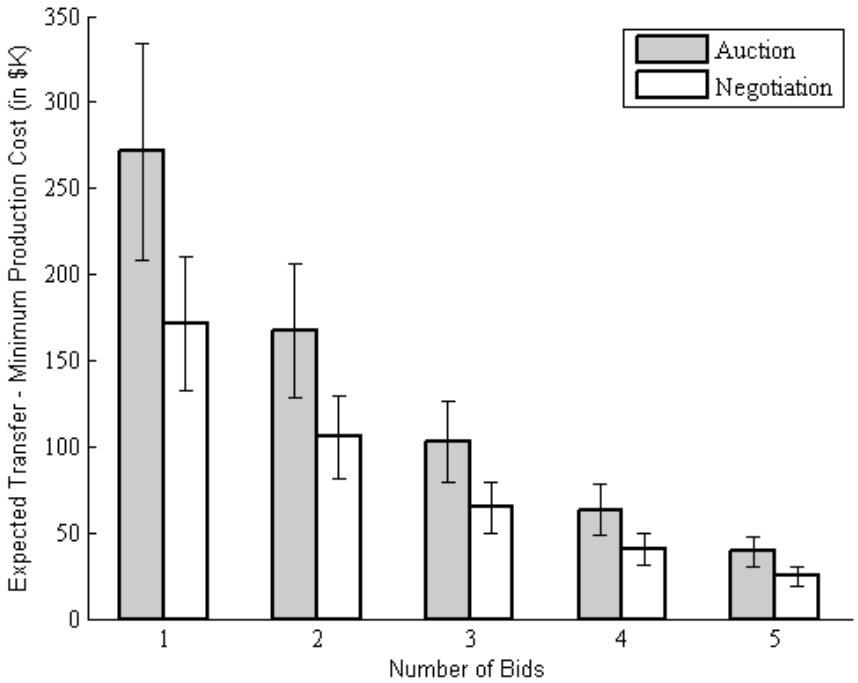
Notes: The numbers in this table are evaluated at the unconditional median value of π_{med}, 0.38.

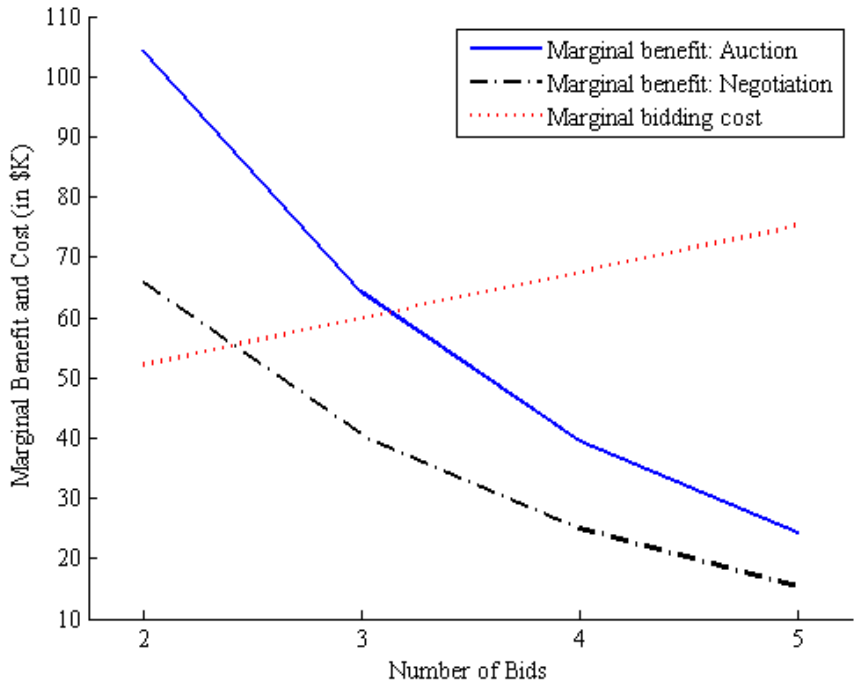
Estimated Endogenous π Distribution



Why So Little Competition: Effective Contract Negotiations

- Negotiating contract terms helps the buyer extract a large portion of informational rent





Why So Little Competition: Effective Contract Negotiations

- What if unilateral price changes are not allowed?
  - (3) Full delegation regarding competition (FPSB auction or no competition & fixed price)
  - (4) Mandated competitive solicitation (FPSB auction only)

(Costs in $ thousand)	Current	(3)	(4)
Number of bids	1.5	+0.7	+1.0
Transfer	1,209.5	+35.8	+12.0
Cost components			
A. Project	1,201.9	-30.3	-45.7
B. Liquidity	3.4	-3.4	-3.4
C. Bidding	16.2	+31.4	+49.7
D. Competitive solicitation	2.5	+6.7	+22.5
Aggregate costs			
A+B	1,205.3	-33.7	-49.0
A+B+C	1,221.5	-2.2	+0.6
A+B+C+D	1,223.9	+4.4	+23.2

Why So Little Competition: Large *Passive* Waste

- Making welfare comparisons hinges on the nature of bidding cost and competitive solicitation cost
- Suppose
  1. Bidding costs reflect market/regulatory frictions, using resources (*passive* waste)
  2. Competitive solicitation costs might reflect corruption or quality (if the former, *active* waste)
- Bandiera, Prat & Valletti (2009) estimate for Italy active waste is up to 11% of transfer; passive waste 15-43%
- We estimate for the US active waste is at most 1-4%; passive 14%

Why So Little Competition: Large *Passive* Waste

- What if more competition is mandated?
  - (1) Mandated competitive solicitation
  - (2) At least two bids

(Costs in $ thousand)	Current	(1)	(2)
Number of bids	1.5	+0.3	+0.8
Transfer	1,209.5	-16.8	-45.7
Cost components			
A. Project	1,201.9	-16.9	-45.0
B. Liquidity	3.4	-0.5	-1.0
C. Bidding	16.2	+14.3	+50.1
D. Competitive solicitation	2.5	+22.5	+22.5
Aggregate costs			
A+B	1,205.3	-17.3	-46.0
A+B+C	1,221.5	-3.0	+4.1
A+B+C+D	1,223.9	+19.5	+26.6

Value of Discretion

- What if the buyer is stripped of all discretion? Competitive solicitation, FPSB auction, fixed-price contracts only
  - (5) Unconditionally optimal rate of promotion ($\lambda = 1.06$)
  - (6) Same as (5) except that bidding costs are halved ($\lambda = 2.48$)

(Costs in $ thousand)	Current	(5)	(6)
Number of bids	1.5	+0.6	+2.0
Transfer	1,209.5	+30.5	-36.4
Cost components			
A. Project	1,201.9	-27.2	-67.6
B. Liquidity	3.4	-3.4	-3.4
C. Bidding	16.2	+46.0	+63.2
D. Competitive solicitation	2.5	+22.5	+22.5
Aggregate costs			
A+B	1,205.3	-30.6	-70.9
A+B+C	1,221.5	+15.4	-7.7
A+B+C+D	1,223.9	+37.9	+14.8

Conclusion

- Develop and identify a procurement model and estimate it using the IT/telecommunications procurement contract data
  - Integrate two important institutional features
    1. Endogenous competition
    2. Ex-post price changes
  - Identify model with unobserved costs and observed project attributes
- Empirical findings:
  - Negotiations on contract terms extract a large portion of the informational rent
  - This reduces the benefit of soliciting more bids compared to bidding and competitive solicitation costs
  - Giving discretion to procuring agencies reduces government cost, even if they are engaging in rent-seeking behavior