Sustainable Intermediation: Using Market Design to Improve the Provision of Sanitation[1]

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February 27, 2020

Motivation

- Despite rapid urbanization, many African countries *under-invest* in public infrastructure
- Consequence: Large portion of urban population is not connected to sewage network and rely on private laterines
- Almost 2 million people in peri-urban Dakar are not connected to the sewage system

Desludging in Senegal

- On average, every 6-12 months households need to *desludge* their pit
- Three technologies:
  - *Mechanical:* Truck + Pump + Treatment center (?)
  - *Family:* Family member + Street or open water
  - *Baaypell:* Hired worker + Street or open water
- Both manual options are *illegal* (rarely enforced)

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- Both manual options are *illegal* (rarely enforced)
- 47% of desludging in Dakar are performed with a truck, 27% by a family member, and 25% by a hired manual

Mechanical versus Manual Desludging

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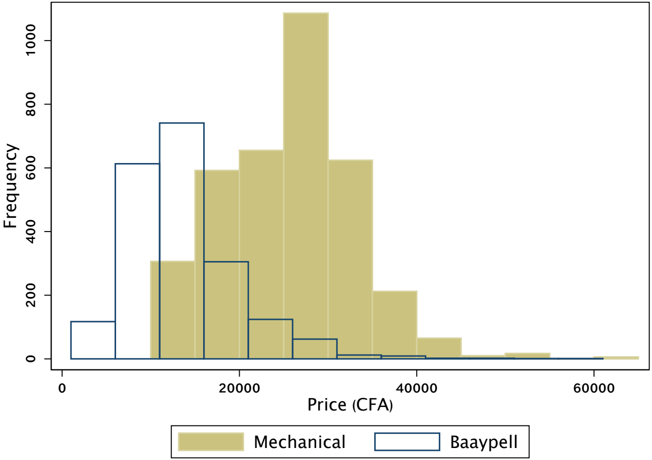
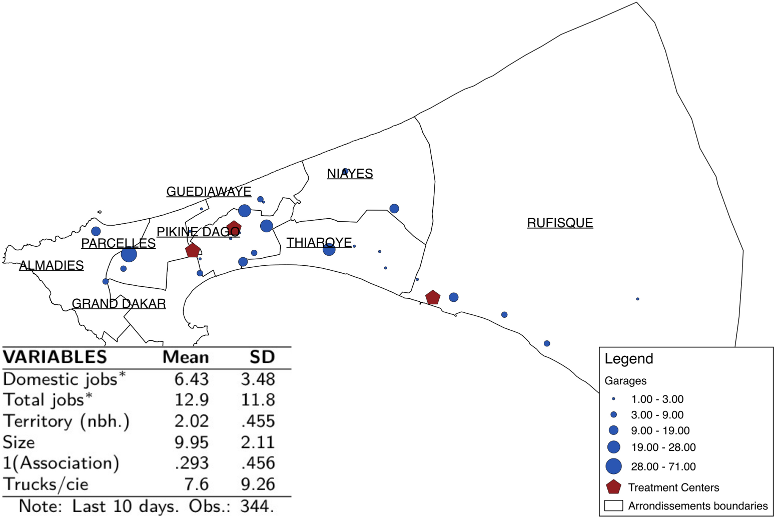
Why? Mechanical Prices are 60% Higher than *Baaypell*



- **Avg. prices in USD:** Manual desludgings cost $28 on average, while mechanical desludgings cost $46 on average.

Market friction: Imperfect competition

Desludgers Characteristics

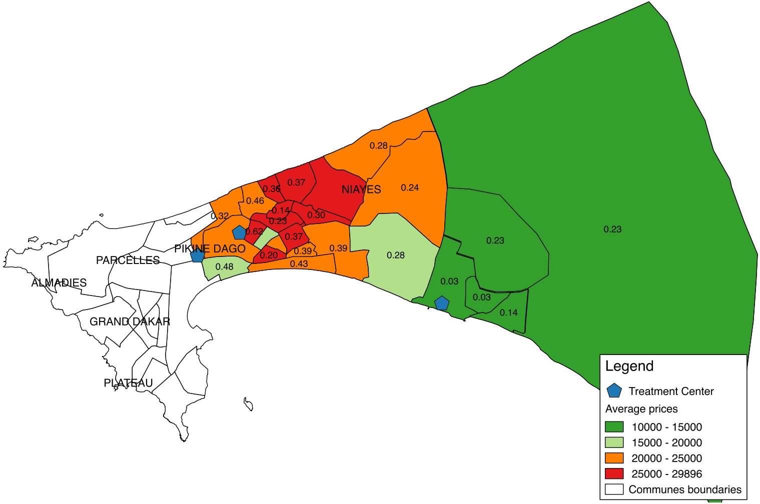


VARIABLES	Mean	SD
Domestic jobs*	6.43	3.48
Total jobs*	12.9	11.8
Territory (nbh.)	2.02	.455
Size	9.95	2.11
1(Association)	.293	.456
Trucks/cie	7.6	9.26

Note: Last 10 days. Obs.: 344.

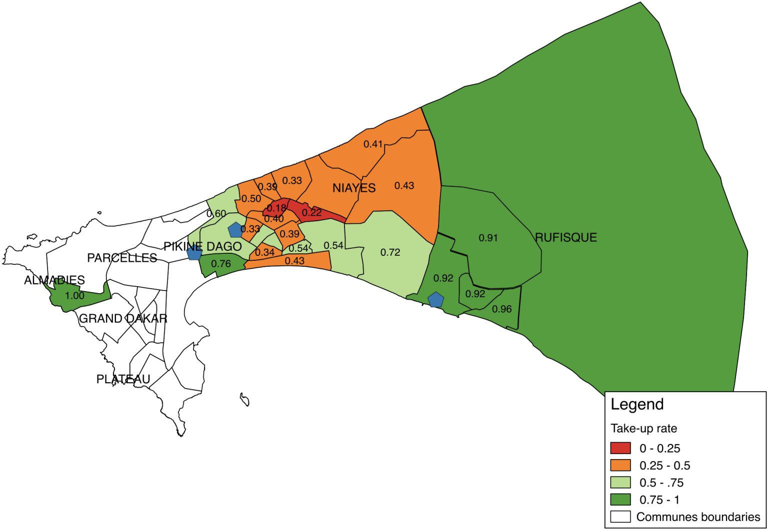
Market friction: Imperfect competition

Average Transaction Prices for Mechanical Services



Market friction: Imperfect competition

Demand for Mechanical Services



Intervention: Just-in-time Auction Platorm

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2. Implement just-in-time procurement auctions for desludging services: invite 8-20 desludgers to over 5,000 between 2013-2016
3. Auction as a “laboratory”: The platform randomizes invitations (how many and which desludgers) + auction format
   - Auction design is *not* optimal

Auction Outcomes: Prices and Acceptance

Nbh.	Avg. auction outcomes			Avg. prices	
	n	Accept	$b_{min} \mid a = 1$	n	prices
Combined*	377	0.43	24.88	60	28.27
Guediawaye	547	0.28	23.87	535	26.20
Niayes	1061	0.20	26.92	1330	25.47
Pikine	399	0.30	20.81	667	23.38
Rufisque	116	0.12	16.21	551	15.92
Thiaroye	1248	0.31	24.14	1608	24.94
Total	3748	1,050	22.03	4751	24.01

Combined: Almadies, Plateau, Grand Dakar, Parcelles.

Price units: CFA/1000.

Research Questions

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- Three questions:
  1. What is the effect of auction competition on prices and transaction probability?
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- Less than 30% of calls end in a successful transaction, and the average clearing price is about \$42. Can we improve on this?
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  3. What would be the non-cooperative equilibrium allocations with competitive auctions (i.e. 40+ invited bidders)?
- We leverage experimental variation in competition and auction format to answer (1) and (2)
- Structural estimate the desldudging cost distribution to answer (3)

Outline

1. Auction Platform
2. Field experiment analysis
   - Competition
   - Collusion
3. Structural model
   - Cost estimation
   - Counter-factual: Competitive auctions
4. Conclusion

Platform Design: Sequence of Actions

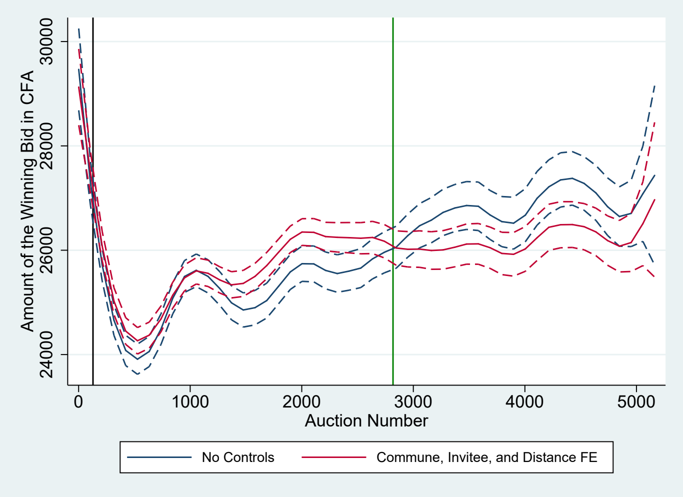
1. Client t calls the platform
2. Auction format (50%): (i) open, or (ii) sealed-bid.
3. Random set of bidders are invited (A_t)
4. Duration = 60 minutes
5. Client is offered the lowest bid, and decides to accept or reject.
6. All bidders are notified of the winning bid (not the identity)

Auction Experiment

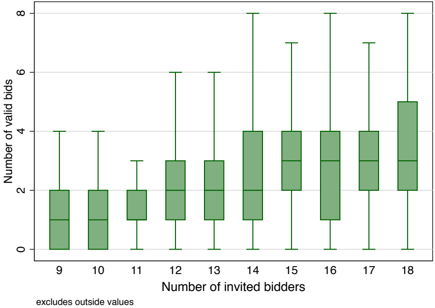
- Common information available to bidders regarding client t (I_t):
  - *Location:* Nearest landmark
  - *Competition:* Number of invited bidders
  - *Time:* Hour, day, month, etc.
- Experimental variation:
  - Format: Open auction (w/ hard closed) *vs* Sealed bid
  - Random invitations: $n \sim U[8, 21]$
  - Distance from garage to client
- Within auction information:
  - *Reminders (minutes):* 15, 30, 40, and 50
  - *Open auction:* Current lowest bid + Minutes left
  - *Sealed-bid auction:* Minutes left
  - *Hard-close:* Last 10 minutes of the open auction is *sealed* (e.g. eBay)

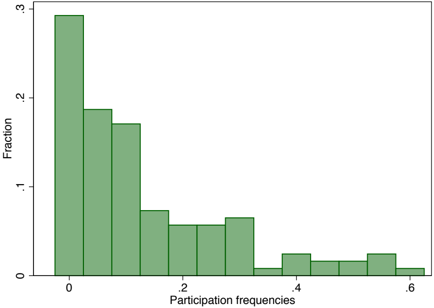
Summary statistics

Feature 1: Average price convergence



Feature 2: Participation Heterogeneity





Analysis 1: Field experiment

1. What is the effect of auction competition on prices and transactions?
2. Are firms able to collude in the auctions? If so, how?

Question 1: What is the effect of competition on prices?

- Expected winning bid and participation:

$$\ln \text{Winning Bid}_t = \alpha_1 n_t + \alpha_2 d_t + \alpha_3 1(\text{Open})_t + x_t\gamma + \epsilon_t$$

$$\text{Number of valid bids}_t = \beta_1 n_t + \beta_2 d_t + \alpha_3 1(\text{Open})_t + x_t\gamma + \epsilon_t$$

Where,

  - Potential bidders (n): (i) all invited, (ii) active bidders
  - Distance from client to garages (d): (i) average (all/active), and (ii) nearest garage (all/active)

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- Acceptance probability: Willingness to pay distribution

$$\text{WTP}_t = x_t \beta + u_t / \sigma, \quad u_t \sim \mathcal{N}(0, 1)$$

$$\Rightarrow \Pr(\text{Accept} | b_t^*, x_t) = 1 - \Phi\left((1/\sigma) \ln \text{Winning Bid}_t - x_t \beta / \sigma\right)$$

Auction competition and winning bids

Units: 1,000 CFA

Winning bid regressions

	(1)	(2)
Mean distance	0.15^{a}	0.053
	(0.040)	(0.041)
Nb. Bidders	-0.17^{a}	-0.13^{a}
	(0.029)	(0.030)
Active		-0.24^{a}
x $1(\leq 10\text{km})$		(0.053)
Min. distance		0.067^{a}
(active)		(0.024)
1(Open)	0.22^{c}	0.25^{b}
	(0.12)	(0.12)

^{a} $p<0.01$, ^{b} $p<0.05$, ^{c} $p<0.1$

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Competition effect

	Competition Low	Competition High
Mean winning bid	29	23
Mean distance	9.8	23
Nb. Bidders	10	16
Active x $1(\leq 10km)$	0	5
Min. distance (active)	18	3
1(Open)	0.66	0.36

Low: $(z_t\hat{\alpha})_{0.95}$. High: $(z_t\hat{\alpha})_{0.05}$

Auction competition and participation

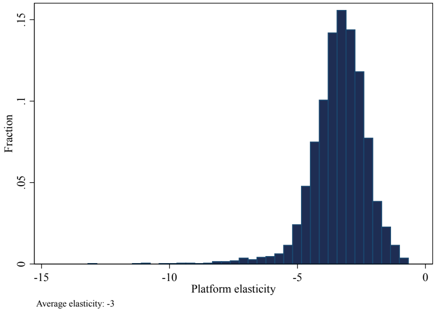
VARIABLES	(1) Nb. Bids	(2) 1(Mono)
Bidders mean distance	0.014	-0.0030
	(0.012)	(0.0041)
Nb. Bidders	0.11[a]	-0.027[a]
	(0.0094)	(0.0030)
Active bidders x Less 10KM	0.17[a]	-0.035[a]
	(0.020)	(0.0056)
Min. distance (active)	-0.0074	0.0064[a]
	(0.0053)	(0.0017)
1(Open)	-0.045	0.029[b]
	(0.038)	(0.012)
Constant	1,634	2,326
	(8,109)	(2,842)
F-test (invitations)	61.4	44.4
Marginal effect (invitation index)	0.42	0.11
Mean dep. variable	1.99	0.44

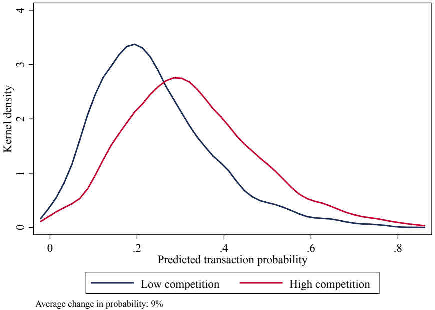
Auction competition and desludging transactions

$$\Pr(\text{Accept}|b_t^*, x_t) = 1 - \Phi\left((1/\sigma)\ln \text{Winning Bid}_t - x_t\beta/\sigma\right)$$

	Reduced-form			Probit	IV-Probit
VARIABLES	(1)	(2)	(3)	(4)	(5)
Active	0.043^b		0.037^c		
x $1(\leq 10km)$	(0.018)		(0.021)		
Min. distance		-0.0083	-0.0026		
active		(0.0061)	(0.0069)		
Winning bid (log)				-0.10^a	-0.12^a
				(0.0080)	(0.042)
Correlation					0.050
Bid and WTP					(0.17)
F-test (invitations)					30.1

Platform demand: Elasticity and competition





Summary: Auction competition results

- Increasing auction competition can lower prices
- Bidder heterogeneity
  - Distance to client is critical for bids and participation
  - Participation: Active (1/3), Occasional (1/3), Never (1/3)
  - Optimal invitation list: Target *active* and *nearby* bidders
- Platform callers are very price sensitive
  - Average elasticity: -3
  - Competition $\uparrow$ take-up rate

Question 2: Are firms colluding in the auctions?

- **Assumption:** Explicit cartel rings are not feasible
  - Random invitations
  - Anonymous bidding
  - Private values
- **Tacit collusion:** Firms commit to strategies that limit competition

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- **Tacit collusion:** Firms commit to strategies that limit competition
- Detecting collusion in auctions
  - *Starting point:* Collusive bids are inconsistent with profit maximization
  - Porter-Zona: Distance and bid ranks
  - Chassang et al.: Missing bids
  - *Implication:* Bidders could $\uparrow$ expected profits by changing bids

Tacit collusion across auction formats

- **Sealed-bid auctions:**
  - *Reference:* McAffee and McMillen (1992)
  - Weak Cartels collude on the reserve price (identical bids)
  - Auction platform = Random assignment (lottery)
  - Our setting: Random reserve price (WTP)

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  - *Claim:* Collusion is more stable is open auctions
  - *References:* Robinson (1985), Graham and Marshall (1987), Athey, Levin and Seira (2011)
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  - Why? Automatic detection + Punishment
  - Our setting: Open auctions with *hard close*
  - Collusive is not necessarily more likely: Prisoner dilemma (sniping)

Collusion detection: Dominated strategies

- Dominated strategies in sealed-bid auctions
  - Avoid "common" bids
  - E.g.: If there is a mass-point at 25, submitting $b = 25$ is **never** optimal
- Dominant strategies in open auctions
  - Undercut if own cost is lower than current lowest bid
  - Submit bid after the last time interval

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- Behavior affected by the degree of collusion
  - *Tying:* Bunching at common negotiated prices in sealed-bid auctions
  - *Undercut:* Bid below current lowest (conditional on participation)
  - *Sniping:* Avoid detection by submitting late bids in open auctions

Detection strategy (continued)

- **Empirical challenge:** Tacit collusion *vs* bounded-rationality
  - Sub-optimal bids can be due to *mistakes* or *non-competitive behavior*
- **Example of mistakes:**
  - Inconsistent estimates of $\Pr(\text{Win}|b)$
  - Frictions: Round prices

Detection strategy (continued)

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- **Example of mistakes:**
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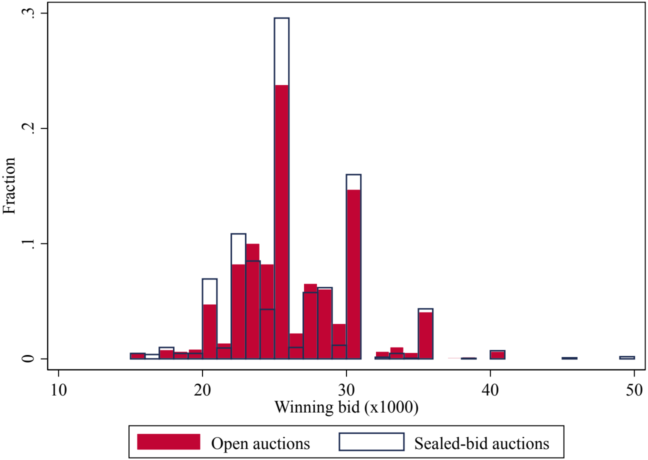
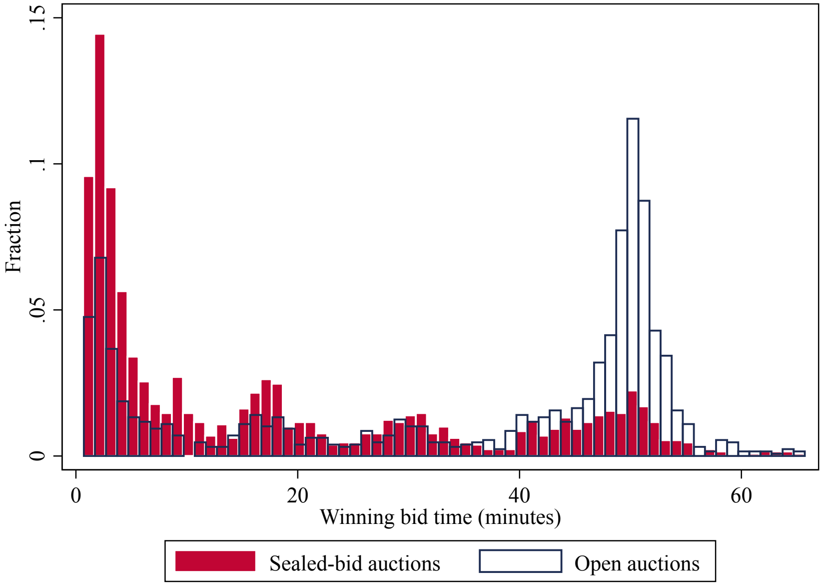
  - Frictions: Round prices
- **Identification:** Random assignment of format and bidder types
  1. *Auction heterogeneity:* Document collusive behavior across formats
  2. *Firm heterogeneity:* Compare behavior of "collusive" and "competitive" bidders across formats

Winning bid distribution across formats



- Common prices: 25, 30, 22, etc.
- Missing density (sealed): 24, 29, 21, etc.

Timing of winning bid across formats



Collusive behavior across formats

	(1)	(2)	(3)	(4)
		Winning bid		First bid
VARIABLES	1(Ties)	1(Round)	1(Sniping)	minutes
1(Open)	-0.09[a]	-0.09[a]	0.3[a]	3.5[a]
	(0.01)	(0.02)	(0.01)	(0.5)
Competition controls	Y	Y	Y	Y
Observations	2,884	4,158	4,158	4,158
R-squared	0.048	0.082	0.147	0.217
Dep. variable	0.2	0.5	0.3	17

Standard errors in parentheses

[a] $p<0.01$, [b] $p<0.05$, [c] $p<0.1$

Collusion *vs* Biased beliefs

- **Hypothesis:** Tie probability in sealed-bid auctions is uncorrelated with the probability of *avoiding competition* in open auctions
- Rejection of this hypothesis is consistent with collusive behavior

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- Rejection of this hypothesis is consistent with collusive behavior
- Why?
  - Common beliefs in open auctions = Current lowest bid
  - "Mistakes" in open auctions are not due to beliefs heterogeneity
  - Negative correlation between "sniping" and "tying"
    - ★ *Competitive* bidders maximize individual profits
    - ★ *Collusive* bidders use dominated strategies
- **Caveat:** Cannot (completely) rule out the possibility that sophisticated bidders are more attentive

Identifying *collusive* types from sealed-bid auctions

- **Sample:**
  - Bids in sealed-bid auctions with 2+ bids received
  - *Active bidders:* Bidders with 30+ valid bids over the sample

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- **Sample:**
  - Bids in sealed-bid auctions with 2+ bids received
  - *Active bidders:* Bidders with 30+ valid bids over the sample
- **Implementation**
  - Dependent variable:

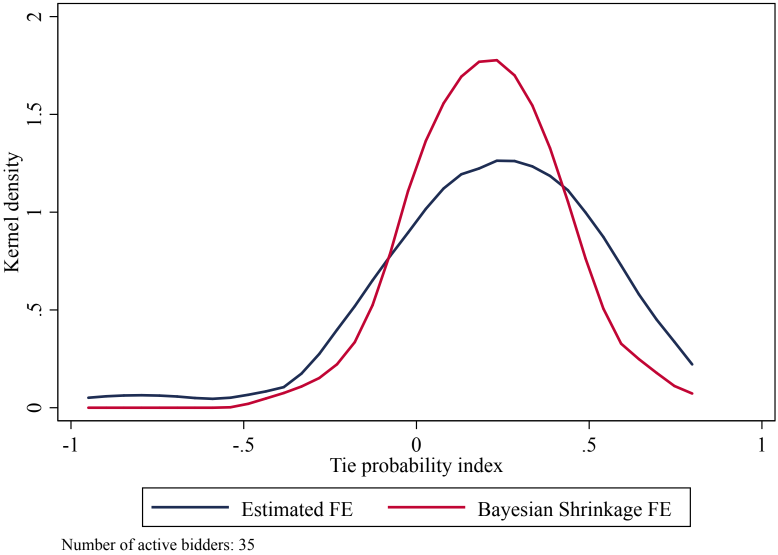
$$y_{it} = \sum_{j \in \mathcal{J}_t \setminus i} 1(b_{it} = b_{jt}) \rightarrow \text{Tie}_{it} = 1(y_{it} > 0)$$

    where $\mathcal{J}_t$ is the set of invited bidders in t.
  - Conditional tie probability (probit)

$$\Pr\left(\text{Tie}_{it} = 1 | x_{it}\right) = \Phi\left(\hat{\theta}_i + x_{it}\hat{\beta}\right)$$

  - Collusive bidder type: $\hat{\theta}_i$

Distribution of tie-probability index $\hat{\theta}_i$



Collusive bidding strategy: Sealed-bid Auctions

	(1)	(2)	(3)
VARIABLES	Bid amount	1(Round bid)	1(Sniping)
Tie FE	0.70^{a}	0.14^{a}	-0.011
	(0.21)	(0.013)	(0.035)
Observations	4,504	4,504	4,504
R-squared	0.234	0.173	0.048
Mean variable	27.1	0.59	0.22
Nb cluster	35	35	35

Robust standard errors in parentheses

^{a} $p<0.01$, ^{b} $p<0.05$, ^{c} $p<0.1$

Collusive bidding strategy: Open Auctions

VARIABLES	(1) 1(Undercut)	(2) 1(Bid above)	(3) 1(Sniping)	(4) Bid time
Tie FE	-0.061[a]	0.028[a]	-0.18[a]	-7.16[a]
	(0.016)	(0.0081)	(0.025)	(1.14)
Observations	1,924	1,924	3,866	3,866
R-squared	0.085	0.041	0.250	0.222
Mean variable	0.37	0.040	0.22	26.8
Nb cluster	35	35	35	35

Robust standard errors in parentheses

[a] $p<0.01$, [b] $p<0.05$, [c] $p<0.1$

(1) and (2) are estimated in the sample of bids placed after a "price message"

Winning bid: Competition & Collusion

VARIABLES	(1) Price	(2) Price	(3) Log Price	(4) Log Price
Avg. tie prob index		0.84^{a}		0.035^{a}
		(0.14)		(0.0054)
Nb. Bidders	-0.13^{a}	-0.12^{a}	-0.0046^{a}	-0.0043^{a}
	(0.028)	(0.028)	(0.0010)	(0.0010)
Active bidders	-0.23^{a}	-0.25^{a}	-0.011^{a}	-0.011^{a}
x Less 10km	(0.049)	(0.048)	(0.0019)	(0.0019)
Min. distance	0.058^{a}	0.068^{a}	0.0019^{a}	0.0023^{a}
	(0.019)	(0.019)	(0.00070)	(0.00070)
1(Open)	0.21^{b}	0.19^{c}	0.0085^{b}	0.0077^{c}
	(0.11)	(0.11)	(0.0040)	(0.0039)
R-squared	0.325	0.331	0.342	0.349
Comp. effect (sd)	0.78	0.89	0.030	0.035

Robust standard errors in parentheses

^{a} $p<0.01$, ^{b} $p<0.05$, ^{c} $p<0.1$

Collusion: Summary

- Ties/snipping is (partially) due to collusion
  - Group of active bidders *avoid* competition (dominated strategies)
  - Collusive bidders: More likely to tie, high bids and less likely to delay
  - Competitive bidders delay bidding in open auctions (not in sealed-bid)
- Bounded rationality unlikely to (fully) explain results
  - Pricing friction: Round prices are less common in open auctions
  - Collusive bidders play dominated strategies in **both** formats

Analysis 2: Bidding in the Sealed-bid Auction

- Bidder i's expected profits from submitting a bid b_i:

$$\pi_{it}(c_{it}) = \max_{b_i \in \mathcal{B}_i} \quad (b_i - c_{it}) D(b_i | I_t) \Pr(Win | b_i, I_t)$$

where $c_{it} = \bar{c}_{it} + \gamma_{it}$ (IPV).

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- **Round bids and ties:** If consideration set is very rich (e.g. $\mathcal{B} = \Re_+$), some bids b_{it} are *dominated* for any $c_{it} \geq 0$ (e.g. $b_{it} = 25K$).
- **Solution:** Partial collusion via limited consideration-sets
  - *Choice-set:* Bids chosen more frequently than 5% by bidder i (6-29)
  - *Implication:* Collusive types have limited consideration sets
  - Sample selection: Bidders who submit at least 20 bids (46 bidders)

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- Bidder i's expected profits from submitting a bid b_i:

$$\pi_{it}(c_{it}) = \max_{b_i \in \mathcal{B}_i} \quad (b_i - c_{it}) D(b_i | I_t) \Pr(Win | b_i, I_t)$$

where $c_{it} = \bar{c}_{it} + \gamma_{it}$ (IPV).

- **Round bids and ties:** If consideration set is very rich (e.g. $\mathcal{B} = \Re_+$), some bids b_{it} are *dominated* for any $c_{it} \geq 0$ (e.g. $b_{it} = 25K$).
- **Solution:** Partial collusion via limited consideration-sets
  - *Choice-set:* Bids chosen more frequently than 5% by bidder i (6-29)
  - *Implication:* Collusive types have limited consideration sets
  - Sample selection: Bidders who submit at least 20 bids (46 bidders)
- Conditional on being invited, bidder i submits an offer if:

$$E_{\gamma_{it}} \left[\pi_{it}(\bar{c}_{it} + \gamma_{it}) | I_t, \bar{c}_{it} \right] > \kappa_{it} + \epsilon_{it}$$

where ϵ_{it} is IPV.

Estimation steps

We'll work backwards through the game/estimation, then discuss the counterfactuals:

1. Desludging cost: $\bar{c}_{it}, F(\gamma_{it})$
2. Outside option: $\kappa_i, G(\epsilon_{it})$
3. Counter-factual: Equilibrium prices with competitive auctions

Step 1: Desludging Cost Estimation

- **Expected profits:** Bidder i's expected profits from submitting a bid b with cost c_{it} with information set I_{it}:

$$\pi_i(b, c_{it}, I_{it}) = \underbrace{\Pr[\text{Win}|b, I_{it}]}_{\text{Pr(Winning)}} \underbrace{D[b|I_{it}]}_{\text{Demand}} \underbrace{(b - c_{it})}_{\text{Margin}}$$

- **Probability of winning:** Let $\tilde{A}_{-i}$ be the number of bids besides i, so

$$\Pr[\text{Win}|b, I_{it}] = \underbrace{\Pr[\tilde{A}_{-i} = 0|I_{it}]}_{\text{Monopolist}} + \underbrace{(1 - \Pr[\tilde{A}_{-i} = 0|I_{it}])}_{\text{Contested auction}} \underbrace{\Pr[\min b_{-i} > b|\tilde{A}_{-i} > 0, I_{it}]}_{\text{Lowest bidder}}$$

- **Beliefs:** Empirical frequency $\widehat{\Pr}[\text{Win}|b_i, I_t] = \Pr(b_{-i} > b_i|I_t)$

Belief example

Cost Estimation: Revealed Preference Inequalities

- For each chosen bid b_{it}:

$$\hat{H}(b_{it}|I_t)(b_{it} - c_{it}) \geq \hat{H}(b'|I_t)(b' - c_{it}), b' \in \mathcal{B}_i$$
$$\rightarrow c_{it} \leq \frac{\hat{H}(b_{it}|I_t)b_{it} - \hat{H}(b'|I_t)b'}{H(b_{it}) - H(b')} = \mu_{it}(b_{it}, b'), \forall b' > b_{it}$$
$$\rightarrow c_{it} \geq \frac{\hat{H}(b' I_t)b' - \hat{H}(b_{it}|I_t)b_{it}}{H(b') - H(b_{it})} = \mu_{it}(b', b_{it}), \forall b' < b_{it}$$

Where $\hat{H}(b_{it}|I_t)(b_{it} - c_{it}) = \widehat{\Pr}[\text{Win}|b_{it}, I_t]\hat{D}[b_{it}|I_t](b_{it} - c_{it})$.

Cost Estimation: Revealed Preference Inequalities

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Where $\hat{H}(b_{it}|I_t)(b_{it}-c_{it}) = \widehat{\Pr}[\text{Win}|b_{it}, I_t]\hat{D}[b_{it}|I_t](b_{it}-c_{it})$.

- If $c_{it} = x_{it}\beta + \gamma_{it}$, the likelihood can be formed as follows:

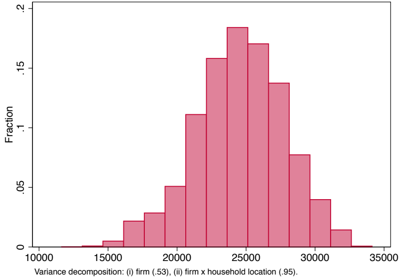
$$\Pr(b_{it} = b_k|I_t, x_{it}) = F(\mu_{it,k} - x_{it}\beta) - F(\mu_{it,k-1} - x_{it}\beta)$$

- Functional form: Mixture-of-normals $F(\gamma)$ (Coppenjans, JoE, 2001).

Estimation Results: Desludging Cost

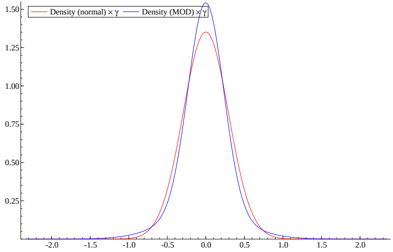
Decomposition: $c_{it} = \bar{c}_{it} + \gamma_{it}, \quad \gamma_{it} \sim F(\gamma;\theta)$

Average desludging cost: $\bar{c}_{it}$



Units: CFA

Private-value component: γ_{it}



Units: 10,000 CFA

Cost estimates

Step 2: Participation Probability Model

- Timing assumption:
  1. Bidders observe: $I_t, \bar{c}_{it}, \kappa_{it}, \epsilon_{it}$
  2. Entry decision: $a_{it} = 1$ if $E(\pi_{it}|\bar{c}_{it}, I_t) > \kappa_{it} + \epsilon_{it}$
  3. If $a_{it} = 1$, each bidder observes γ_{it} and submits b_{it}

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- Expected profits based on the limited choice-set:

$$E(\pi_{it}|\bar{c}_{it}, I_t) = \int \max_{b' \in \mathcal{B}_i} \hat{H}(b')(b' - \bar{c}_{it} - \gamma)f(\gamma|\hat{\theta})d\gamma)$$

where $\bar{c}_{it} = x_{it}\hat{\beta}$.

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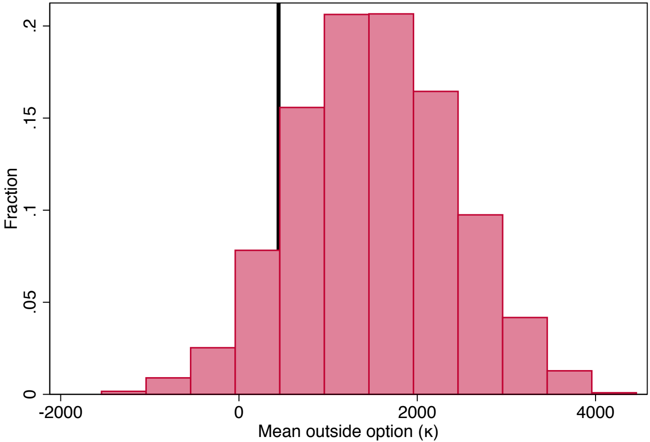
  where $\bar{c}_{it} = x_{it}\hat{\beta}$.
- If $\epsilon_{it} \sim N(0, \sigma_\epsilon^2)$ and $\kappa_i = z_i\delta$, this leads to a standard Probit model:

$$\Pr(a_{it} = 1|I_{it}, x_{it}, z_{it}) = \Phi\left(\frac{E(\pi_{it}|\bar{c}_{it}, I_t) - z_{it}\delta}{\sigma_\epsilon}\right)$$

Average Outside Options – κ_{it} (Units: CFA)

Vertical line = Expected platform profits (450)



Variance decomposition: (i) hour and day (.02), (ii) hour, day and month (.28). Corr(k,c)= -.21.

Entry cost estimates

Step 3: Counter-factual Platform Design

- **Goal:** What would be the non-cooperative equilibrium allocations with competitive auctions (i.e. 40+ invited bidders)?

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  - Firms decide to enter simultaneously and non-cooperatively
- Using the revelation principle (Myerson,1981), the incentive compatible expected payment to firm i is:

$$E_{\tilde{A}_t,\gamma_t,w_t}\left[P_{it}(\gamma_{it},\gamma_{-i,t},w_t,\tilde{A}_t)\,(\bar{c}_{ij}+\psi(\gamma_{it}))\,\middle|A_t\right]$$

- Where,
  - $P_{it}(\gamma_{it},\gamma_{-i,t},w_t,\tilde{A}_t)$ is a (non-increasing) probability of selecting firm i
  - $\tilde{A}_t$ is the set of bidders competing for client t
  - $\bar{c}_{ij}+\psi(\gamma_{it})=\bar{c}_{it}+\gamma_{it}+\frac{F(\gamma_{it})}{f(\gamma_{it})}$ is the *informationally* adjusted cost of i

Step 3: Counter-factual Platform Design

- The expected profit conditional on participating is:

$$\bar{\pi}_{ij}(A_t) = E_{\tilde{A}_{it},\gamma_i,w_i}\left[\int_{\gamma_{ij}}^{\infty} P_{ij}(z,\gamma_{i,-j},w_i,\tilde{A}_{it})dz \middle| A_t\right] \text{ (Ass.: Efficient selection.)}$$

$$= E_{\tilde{A}_{it},\gamma_{it}}\left[\underbrace{\int_{\gamma_{ij}}^{\infty} D_i(\bar{c}_{ij}+\psi(z))\,\Pr\left(\min_{k\in\tilde{A}_{it}} \bar{c}_{kt}+\psi(\gamma_{kt}) > c_{it}+\psi(z)\right)dz}_{E(\pi_{it}|\gamma_{it},\tilde{A}_s)} \middle| A_t\right]$$

where the distribution of $\tilde{A}_{it}$ is derived from the entry prob. of rivals.

- **Bayes-Nash equilibrium:** Participation is consistent with $\bar{\pi}_{it}(A_t)$,

$$\rho_{it}(I_t, A_t) = \Phi\left(\frac{\bar{\pi}^{\rho}_{in}(A_t) - \kappa_i}{\sigma_\epsilon}\right).$$

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$$\rho_{it}(I_t, A_t) = \Phi\left(\frac{\bar{\pi}^{\rho}_{in}(A_t)-\kappa_i}{\sigma_\epsilon}\right).$$

- **Solution algorithm:** (Importance sampling)
  - Compute $E_{\gamma_{it}}(\pi_{it}|\tilde{A}_s)$ for random list $s = 1,\dots,S$ (independent of ρ).
  - At iteration k, evaluate the probability of observing each $\tilde{A}_s$ using ρ^{k-1}_{it}
  - Update the best-response of each player until convergence

Counter-Factual Results: Comparison to Current Platform

Invitation list: Every active bidders (46)

		Counter-factual			Observed platform (sealed)		
Nbh.	N	Offers	Entry Freq.	Accept Freq.	Offers	Entry Freq.	Accept Freq.
Almadies	81	16.82	0.25	0.76	24.60	0.16	0.42
Dakar Plateau	23	20.03	0.21	0.67	27.95	0.13	0.30
Grand Dakar	34	17.33	0.23	0.62	23.38	0.18	0.21
Parcelles	68	14.50	0.27	0.89	22.05	0.19	0.46
Guediawaye	296	17.91	0.30	0.62	24.54	0.18	0.27
Niayes	631	21.32	0.27	0.47	28.17	0.13	0.25
Pikine	205	16.43	0.28	0.60	22.28	0.20	0.33
Rufisque	81	24.25	0.18	0.08	25.51	0.08	0.05
Thiaroye	683	18.02	0.28	0.67	24.98	0.18	0.33
Total	2102	18.93	0.27	0.58	25.53	0.16	0.29

Notes: Price units: 1,000 CFA. Sample: Sealed-bid auctions. Specification: Heterogenous belief model (1).

Counter-Factual Results: Comparison to Market Prices

Invitation list: All active bidders (46)

Nbh.	N	Counter-factual Offers	Counter-factual Entry Freq.	Counter-factual Accept Freq.	Average transac. prices
Combined*	206	16.50	0.25	0.77	28.27
Guediawaye	296	17.91	0.30	0.62	26.20
Niayes	631	21.32	0.27	0.47	25.47
Pikine	205	16.43	0.28	0.60	23.38
Rufisque	81	24.25	0.18	0.08	15.92
Thiaroye	683	18.02	0.28	0.67	24.94
Total	2102	18.93	0.27	0.58	24.01

Notes: Price units: 1,000 CFA. Sample: Sealed-bid auctions. Specification: Heterogenous belief model (1). Combined arrondissements: Almadies, Plateau, Grand Dakar, Parcelles.

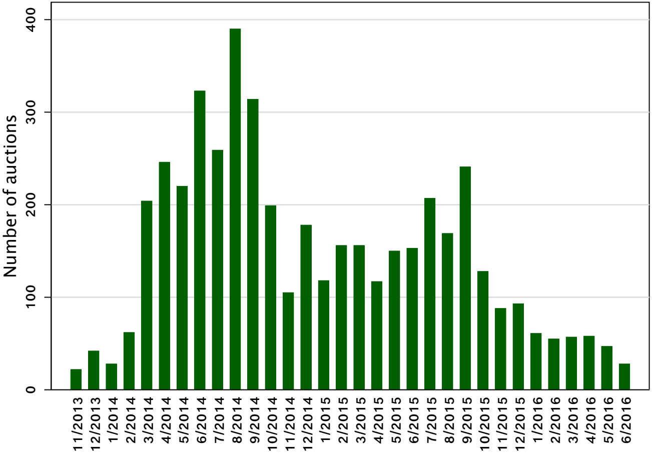
Conclusion

- Market-based solution to a development problem
- Randomization provides great instruments
  - Identify demand/WTP
  - Measure the effect of competition/collusion
- Firms make low expected profits, driving low participation, but have high margins, and consumers are very elastic
- The lowest cost firms have high outside option value, drop out of the market relatively quickly
  - *Some rents must be left on the table in order to convince the highest productivity firms to continue to participate.*

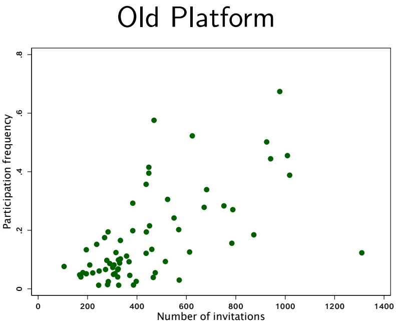
Summary Statistics

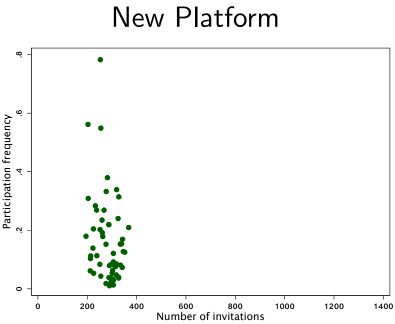
	Old paltform		New platform	
	Average	SD	Average	SD
Nb. of auctions	2669		2005	
Nb. of clients	2488		1680	
Nb. of completed jobs	862		481	
Auction format = Open	0.501	0.500	0.495	0.500
Probability of bidding	0.115	0.153	0.102	0.140
Invited auctions per firm	352	240	239	102
Number of firms	109		92	
Number of potential bidders	14	2	11	2
Valid bids per successful auction	2.878	1.529	1.848	1.042
Auctions with zero bids (%)	0.069	0.254	0.283	0.450

Number of Auctions per Month



Total Invitations per Desludger

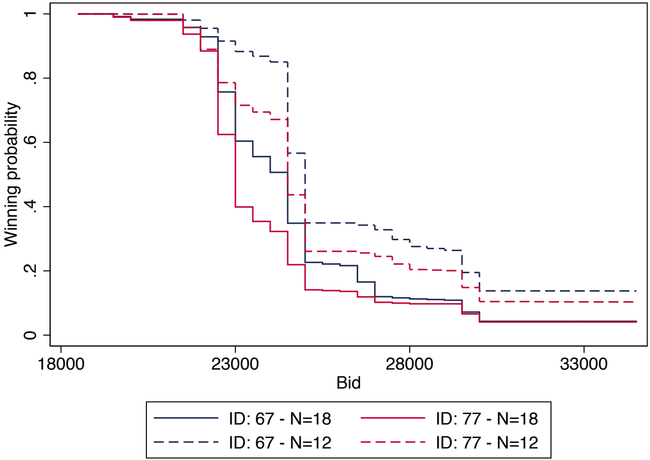




Return

Example: Win probability for two bidders and two auctions

Beliefs = Heterogenous



Return

Estimation Results: Desludging Cost Distribution

VARABLES	Beliefs: Heterogeneous (1)	(2)	Beliefs: Open auction (3)	(4)
Distance (km)	0.020	0.020	0.021	0.021
	(0.001)	(0.001)	(0.001)	(0.001)
Association	0.261	0.261	0.215	0.214
	(0.020)	(0.020)	(0.020)	(0.020)
1(Single truck)	0.088	0.087	0.081	0.081
	(0.011)	(0.011)	(0.011)	(0.011)
Nb. Trucks	0.058	0.058	0.062	0.062
	(0.005)	(0.006)	(0.006)	(0.006)
Nb. bidders invited		0.001		0.002
		(0.001)		(0.001)
% invitees same garage		-0.034		-0.070
		(0.027)		(0.027)
Mixture weight: type 1	0.796	0.197	0.865	0.880
Location: type 2	-0.031	-0.028	-0.005	0.048
Std-deviation: type 1	0.230	0.231	0.256	0.279
Std-deviation: type 2	0.504	0.509	0.575	0.585
% violations	0.063	0.063	0.037	0.037
LLF/N	-2.334	-2.334	-2.156	-2.156

Control variables (FE): neighborhood, garage, company, month, year, dow, and client lat/long coordinates (continuous). Mean bid: 2.71.

Return

Estimation Results: Participation Probability Model

	Beliefs: Heterogeneous		Beliefs: Open auction	
	(1)	(2)	(3)	(4)
Expected profits	6.96	6.96	5.39	5.38
	(0.50)	(0.50)	(0.38)	(0.38)
Association	0.51	0.51	0.45	0.45
	(0.08)	(0.08)	(0.07)	(0.07)
1(Single truck)	0.19	0.19	0.17	0.17
	(0.05)	(0.05)	(0.05)	(0.05)
Nb. Trucks)	0.07	0.07	0.07	0.07
	(0.02)	(0.02)	(0.02)	(0.02)
Indicator: Lunch	-0.09	-0.09	-0.06	-0.06
	(0.03)	(0.03)	(0.03)	(0.03)
Indicator: Afternoon	-0.14	-0.14	-0.09	-0.09
	(0.05)	(0.05)	(0.05)	(0.05)
Nb. bidders invited		0.01		0.01
		(0.01)		(0.01)
% invitees same garage		-0.04		-0.05
		(0.13)		(0.13)
$\hat{\sigma}_\epsilon$	0.144	0.144	0.186	0.186
LLF/N	-0.476	-0.476	-0.473	-0.473

Controls (FE): garage, company, month, year, and dow. Units: x10,000 CFA.

Return