Understanding indicative bidding: an experimental approach

Changxia Ke* Gregory Kubitz* Yang Liu†

*Queensland University of Technology
†Deloitte

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Motivation

- In many auctions, the value of the target asset is difficult to estimate.
- Bidders need to conduct costly due diligence to determine the value of the target asset.
  - Example: Takeover auctions (Gentry and Stroup, 2019)
    - The value of the target firm is affected by its business performance, financial situation, legal issues and etc.
    - Buyers hire professional team to assess this information.
- Sellers indirectly bear these costs:
  $\rightarrow$ Bidders are less willing to participate
  $\rightarrow$ Lower winning bid/revenue

Motivation

- Limiting the number of bidders into the auction can increase participation and revenue (Milgrom, 2004)
  - Bidders avoid paying the cost of due diligence when they have a low chance of winning
- Restricting number of entrants requires a process of selecting bidders from pool of willing participants
  - A process that selects the highest valued pariticipants will increase revenues
- Indicative bidding: indicate interest without commitment to bid in auction stage
  - Ye, 2007; Kagel et al, 2009; Quint and Hendricks, 2018

Virgin Australia takeover

Virgin Australia bidders narrowed down to two: Bain and Cyrus Capital Partners

By business reporter Nassim Khadem

Posted Tue 2 Jun 2020 at 4:22pm, updated Wed 3 Jun 2020 at 12:21am

Source: ABC News: Giulio Saggin

Notice buyers

- 20 are interested
- 5 parties are invited

Indicative bids

- 5 parties made non-binding indicative bids based on signal they have

Selection

- 2 are shortlisted based on their indicative bids
  - Bain & Cyrus

This paper

- Use lab experiment to compare three selection mechanisms under both low and high entry costs
  - Unrestricted Entry - No entry restrictions
  - Restricted Entry - Entry restrictions with random selection
  - Indicative Bidding - Entry restrictions with selection based on level of interest
- Counterfactual analysis relative to Unrestricted Entry
  - Pariticipation effect - Revenue change from potential bidders' willingness to participate in an auction
  - Selection effect - Revenue change associated with ability to select participants with the highest valuations

Overview of results

- Restricted Entry generates lower (equal) revenue than Unrestricted Entry when entry cost is low (high)
  - "Mistakes" in entry choices worsen the revenue loss from the selection process relative to theortical predictions.
- Indicative Bidding generates higher (equal) revenue than Unrestricted Entry when entry cost is high (low)
  - Large positive participation effect when entry cost is high
- Indicative Bidding generates higher revenue than Restricted Entry
  - Higher participation rather than improved selection

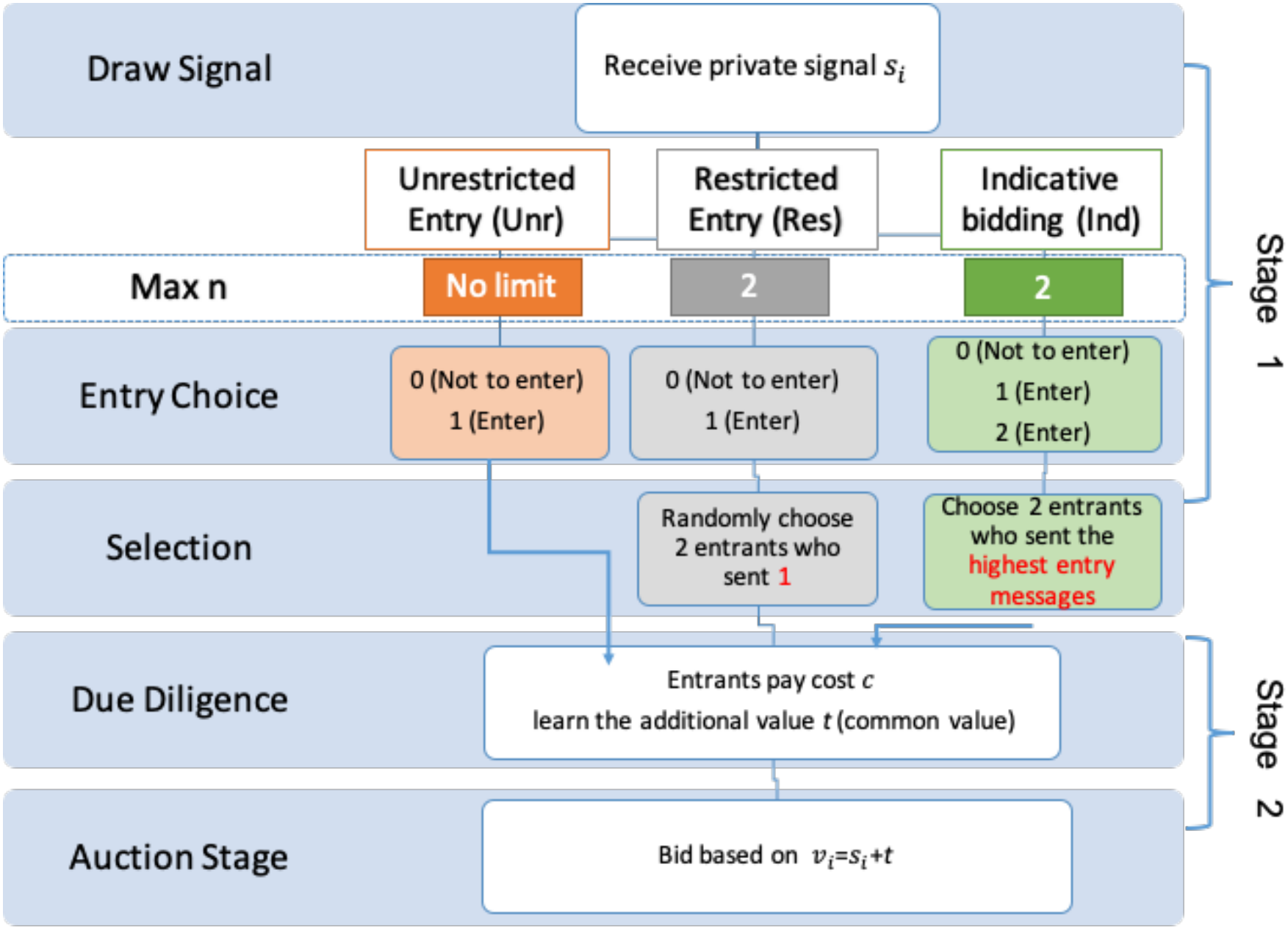
Framework

- $N = 5$ potential bidders, n entrants
- Private value $v_i = s_i + t$
  - Pre-entry iid signal $s_i \in U[0, 100]$
  - Post-entry perfectly correlated signal $t = 0$, 100 and 200 with 25%, 50% and 25% chance respectively
- Second price auction with no reserve price
- Entry cost $c \in \{5, 25\}$
- Selection mechanism/treatment $T \in \{Unr, Res, Ind\}$
- Message $M \in \{0, 1, 2\}$

Equilibrium results follow from Quint and Hendricks (2018)

- Unique symmetric equilibrium in partition strategies: signal intervals map to entry decisions
- Equilibrium characterized by cutoffs α_M^T

Three entry mechanisms



Equilibrium: unrestricted entry

- Bidder i with signal $s_i = \alpha_1^{Unr}$ should be indifferent between choosing 1 (Enter) and 0 (Not to enter):

$$\pi(\alpha_1) = \alpha_1^{N-1}(\alpha_1 + E(t) - c) + \sum_{k=1}^{N-1} p_k \cdot (-c) = 0$$

Where p_k is the probability of having k opponent(s)

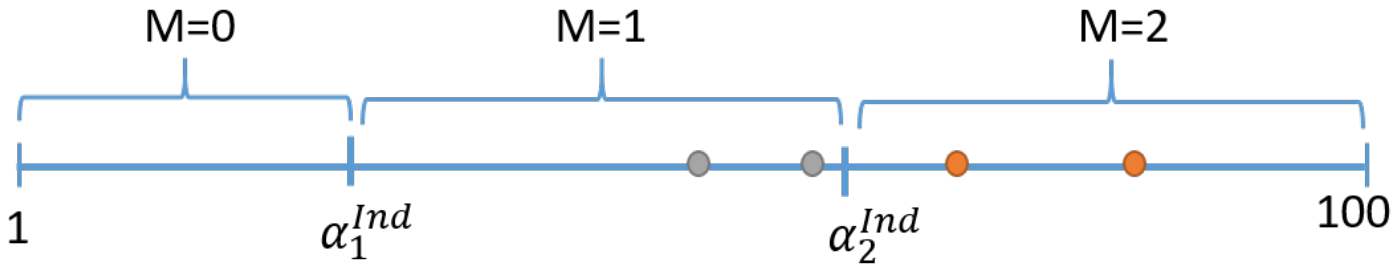
Equilibrium: restricted entry

- Bidder i with signal $s_i = \alpha_1^{Res}$ is indifferent between choosing 1 (Enter) and 0 (Not to enter):

$$\pi(\alpha_1) = \alpha_1^{N-1}(\alpha_1 + E(t) - c) + \sum_{k=1}^{N-1} p_k \cdot \frac{2}{k+1} \cdot (-c) = 0$$

Equilibrium: indicative bidding

- Bidder i with signal $s_i = \alpha_M^{Ind}$ is indifferent between choosing $M-1$ and M:



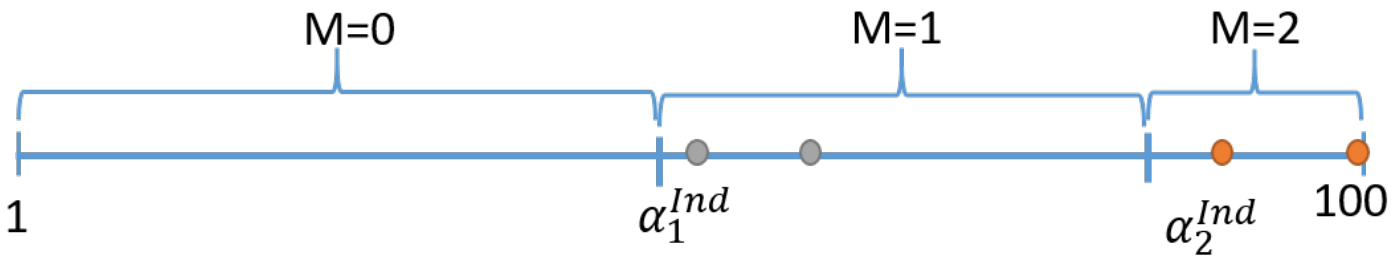
Indifference conditions for cut-off types

$$\pi(\alpha_1, M=1) = \pi(\alpha_1, M=0) = 0 \tag{1}$$

$$\pi(\alpha_2, M=1) = \pi(\alpha_2, M=2) \tag{2}$$

Equilibrium: indicative bidding

- $M = 2$ increases chance of entering when others are participating
- When the entry cost is high, $c = 25$, all interested participants have high values and bidders never choose $M = 2$



- Under high cost condition *Ind* and *Res* have same equilibrium

Experimental implementation

- 3 treatments ($T \in \{Unr, Res, Ind\}$) vary between subjects
- 2 cost conditions (high-cost and low-cost) vary within subjects
  - Round 1-10: c=5 and Round 11-20: c=25
- Fixed group of 5 people for each cost condition
- 1 round is randomly selected for payment

- Conducted in November, 2019 in Hangzhou, China
  - 360 participants: 30 participants $\times$ 4 sessions per treatment
  - Sessions lasted 1 to 1.5 hours
  - The average payment is 75 RMB (AUD 15 - 18)

Hypothesis 1

Revenue ranking

The relative revenue ranking of the three treatments depends on the entry-cost condition.

When entry cost is low, $R^{Ind} > R^{Unr} > R^{Res}$

When entry cost is high, $R^{Ind} = R^{Res} > R^{Unr}$

Table 1: Theoretical predictions

	c=5			c=25		
	Unr	**Res**	**Ind**	**Unr**	**Res**	**Ind**
α_1	43.23	38.74	35.50	62.62	59.28	59.28
α_2			77.59			-
Revenue	151.39	146.79	155.77	109.89	116.73	116.73

Hypothesis 2 and 3

$Rev(\alpha^T, \tilde{T})$ is revenue using equilibirum messsage strategies in treatment T and selection process in treatment $\tilde{T}$

Participation Effect

$$PE^T = Rev(\alpha^T, Unr) - Rev(\alpha^{Unr}, Unr)$$

When entry cost is low, $PE^{Ind} > PE^{Res} > 0$;
When the entry cost is high, $PE^{Ind} = PE^{Res} > 0$.

Selection Effect

$$SE^T = Rev(\alpha^T, T) - Rev(\alpha^T, Unr)$$

When the entry cost is low, $SE^{Res} < SE^{Ind} < 0$;
When the entry cost is high, $SE^{Res} = SE^{Ind} < 0$.

Revenue ranking: intuition

Revenue rankings depend on which effect dominates

- Restricted Entry
  Selection effect dominates with low cost: $R^{Res} < R^{Unr}$
  Participation effect dominates with high cost: $R^{Res} > R^{Unr}$

	c=5			c=25		
	Unr	**Res**	**Ind**	**Unr**	**Res**	**Ind**
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Participation		5.15	8.00		9.49	9.49
Selection		-9.75	-3.62		-2.65	-2.65

Revenue ranking: intuition

Revenue rankings depend on which effect dominates

- Restricted Entry
  Selection effect dominates with low cost: $R^{Res} < R^{Unr}$
  Participation effect dominates with high cost: $R^{Res} > R^{Unr}$
- Indicative Bidding
  Participation effect always dominates: $R^{Ind} > R^{Unr}$

	c=5			c=25		
	Unr	**Res**	**Ind**	**Unr**	**Res**	**Ind**
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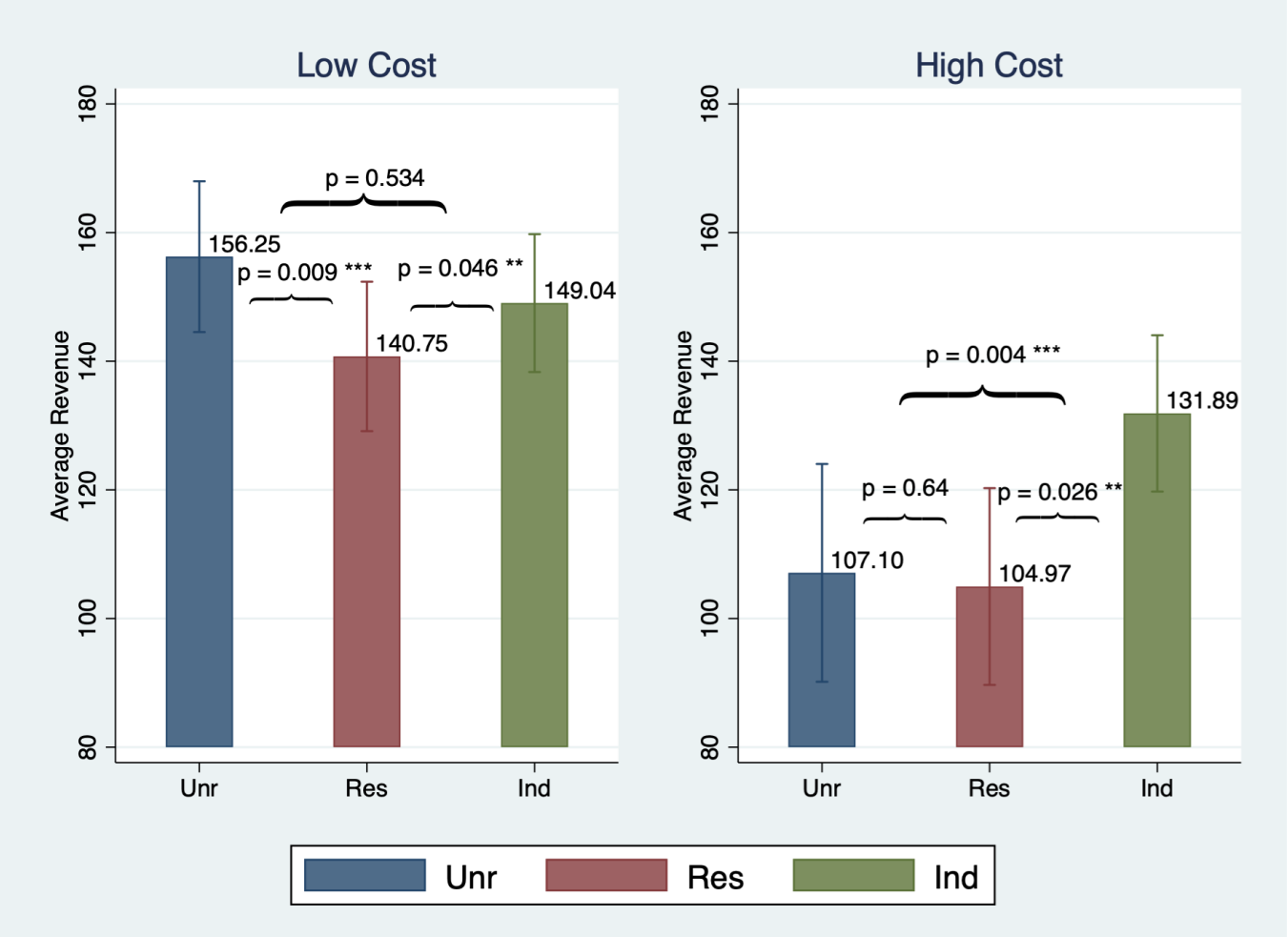
Results: revenue



Result 1: When the entry cost is low, $R^{Ind} \approx R^{Unr} > R^{Res}$;
When entry cost is high, $R^{Ind} > R^{Unr} \approx R^{Res}$.

Table

Results: bidding behaviour

Figure 1: Scatter plot of bidding

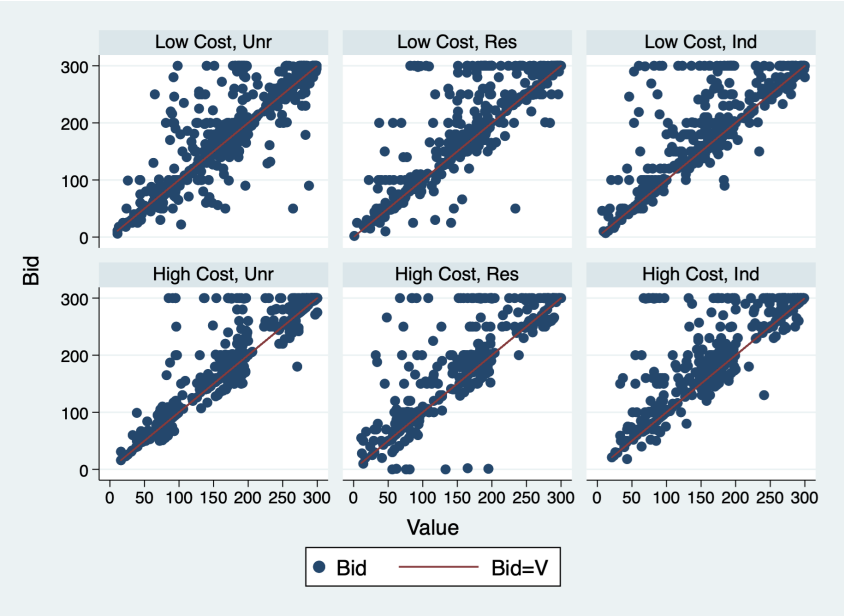


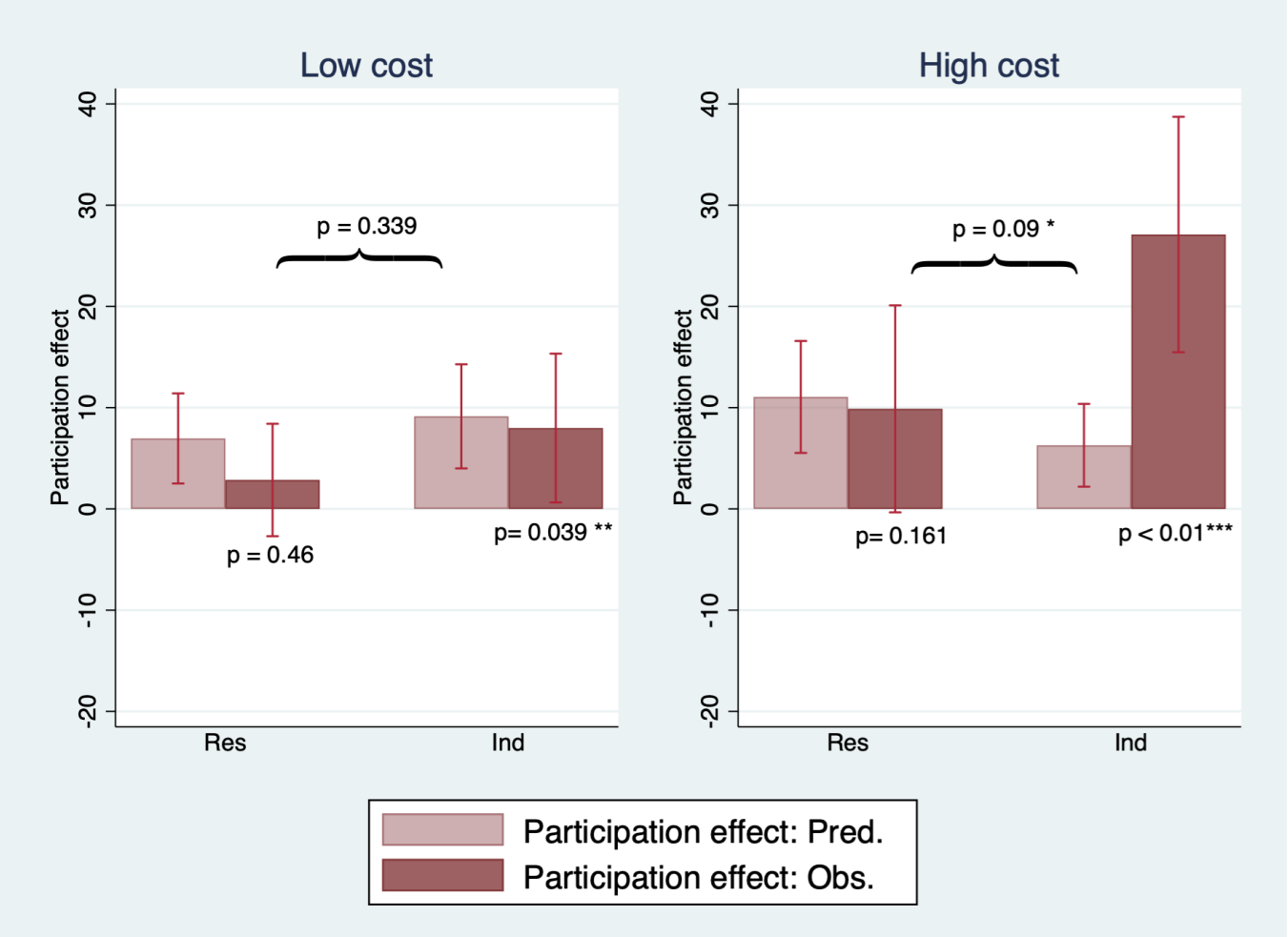
Table 2: Mixed regression

	Overbid: Bid/v	
	Lowcost	Highcost
Unr	1.208**	1.259***
	(0.102)	(0.086)
Res	1.263**	1.361***
	(0.104)	(0.085)
Ind	1.392***	1.38***
	(0.105)	(0.083)

* indicate the significance of Wald test comparing regression coefficients with no overbid. (overbid=1).

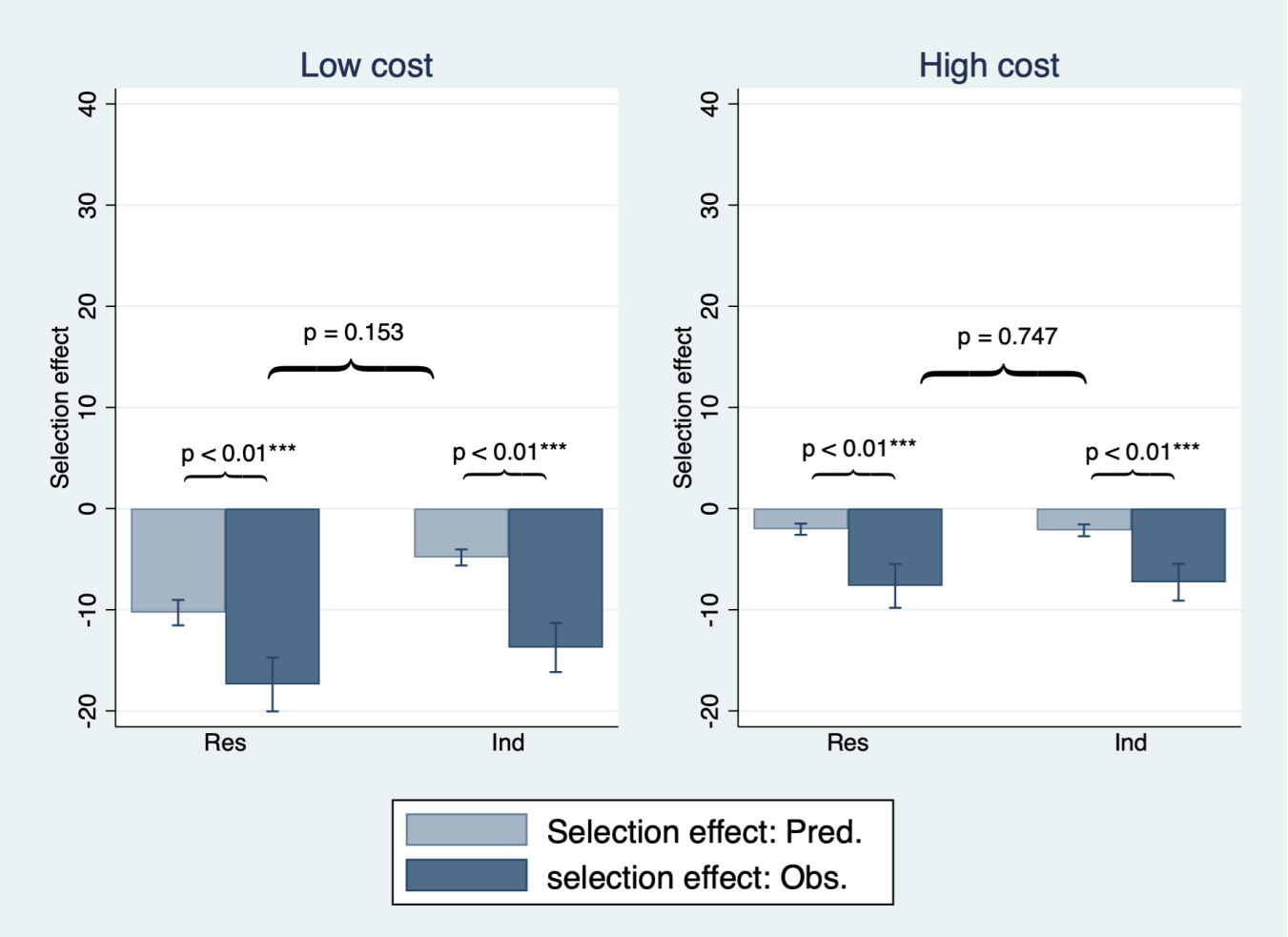
Result 4: We observe significant overbid in all treatments and the magnitude of overbidding is not significantly different across treatments.

Results: participation effect



Result 2: Only PE^{Ind} are significantly positive;
High c: $PE^{Ind} > PE^{Res} \rightarrow R^{Ind} > R^{Res}$ Table Regression

Results: selection effect



Result 3: The size of SE is always bigger than what is predicted;
Larger $SE \rightarrow R^{Ind} \approx R^{Unr}$ in low cost;
$\rightarrow R^{Res} \approx R^{Unr}$ in high cost;

Table Regression

Results: entry behaviour

- Entry choice breakdown

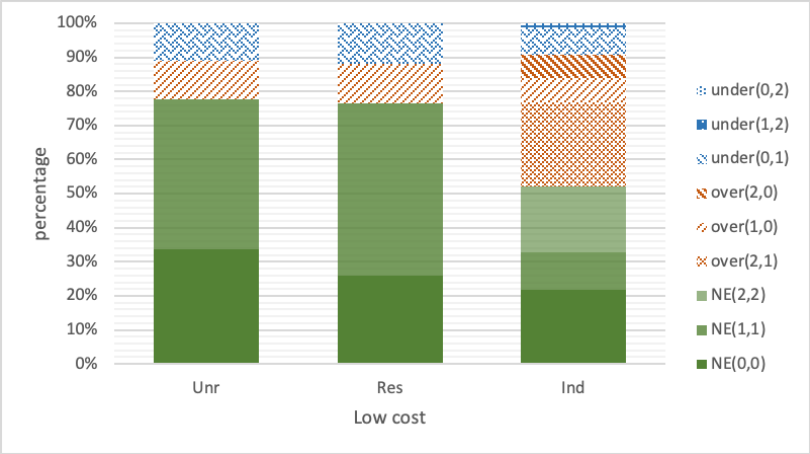


Figure 2: Low cost

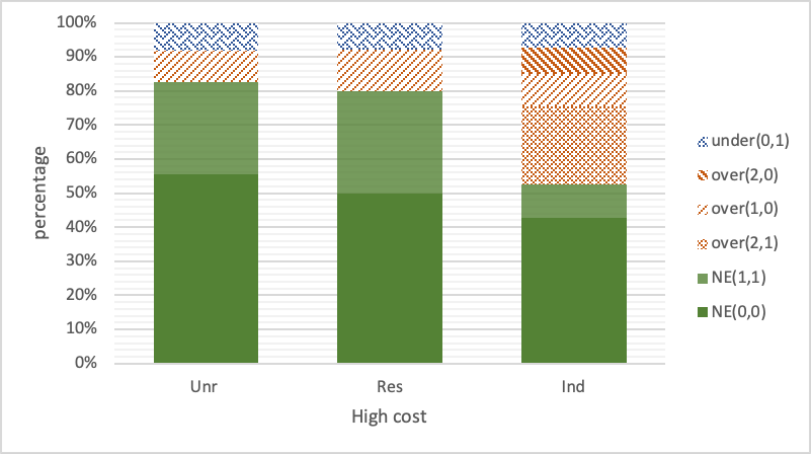


Figure 3: High cost

- In *Unr* and *Res*, around 80% of the time participants plays the NE. In *Ind*, the ratio is lower (around 50%).

Results: entry behaviour

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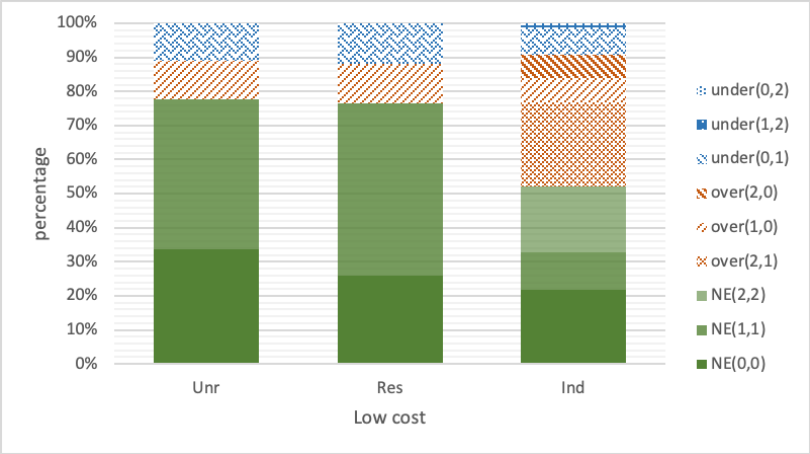

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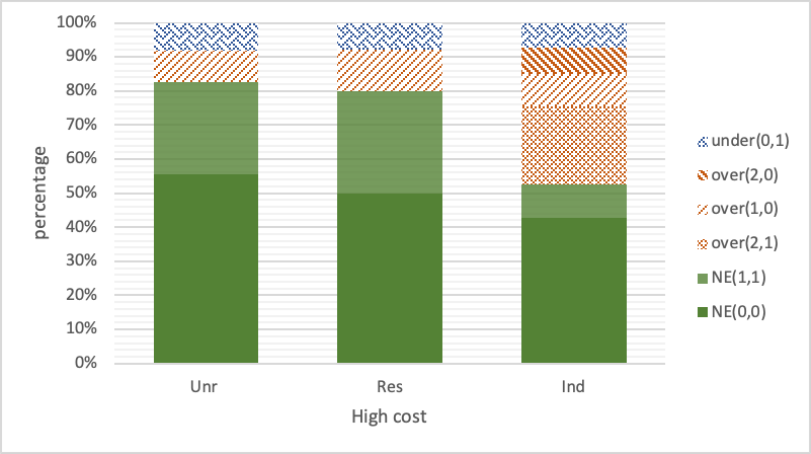

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- In *Unr* and *Res*, around 80% of the time participants plays the NE. In *Ind*, the ratio is lower (around 50%).
- The deviation in *Ind* is mostly caused by participants who chose message 2 when they should have chosen 1 (23.58%).

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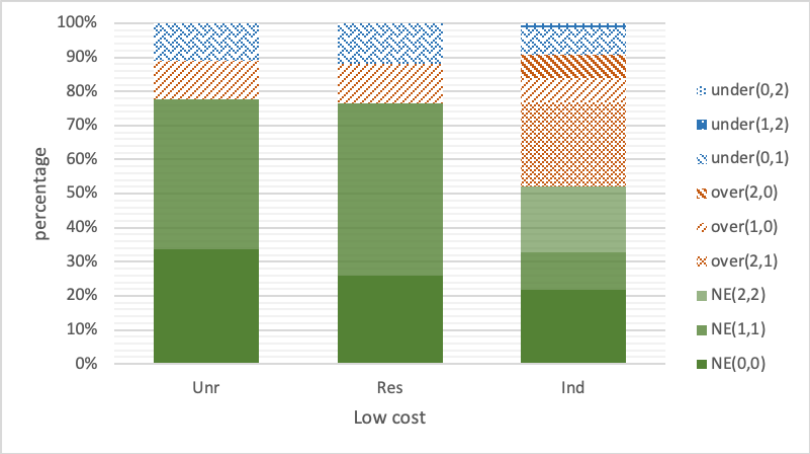

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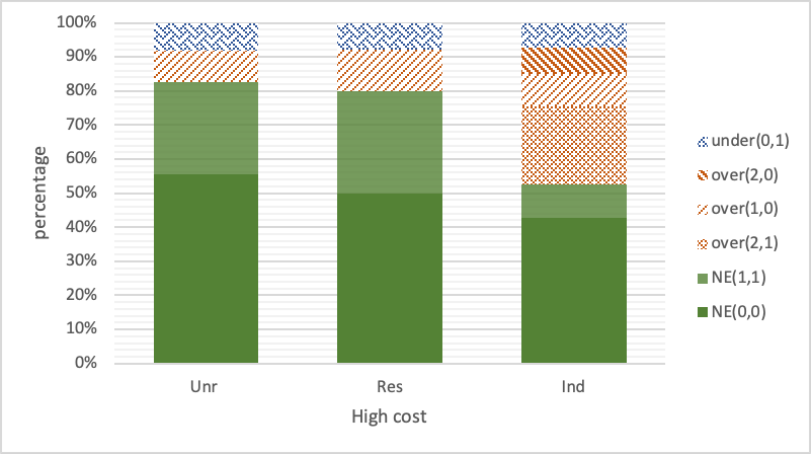

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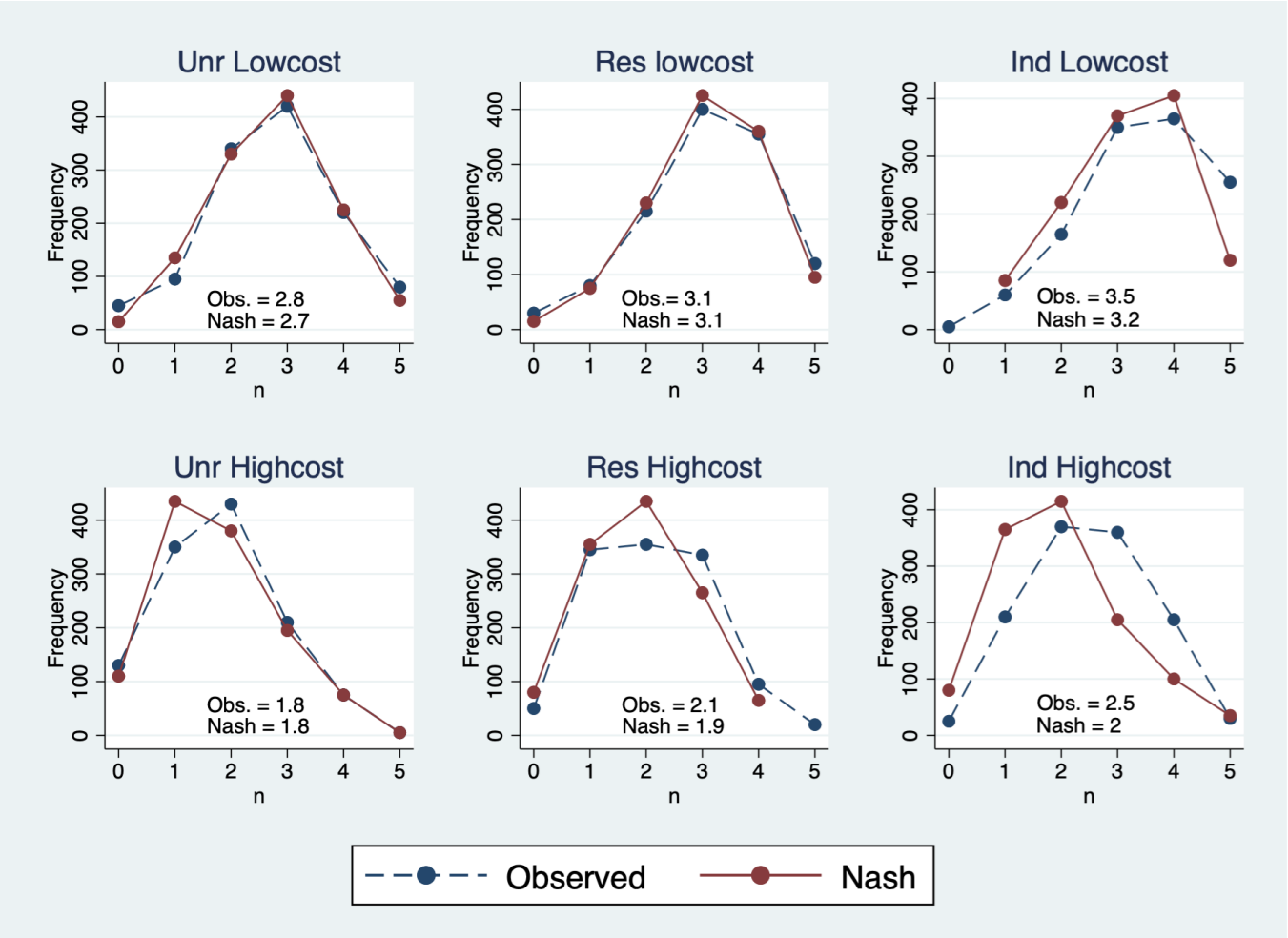
- The deviation in *Ind* is mostly caused by participants who chose message 2 when they should have chosen 1 (23.58%).
- Non-equilibrium entry choices in *Res* and *Ind* contribute to more inefficiency in selection (larger negative SE)

Results: number of participants who chose to enter



- Explains the larger than predicted *PE* for *Ind* with high cost
  - Fewer cases of 0 or 1 interested bidders compared with equilibrium (19.58% vs 37.09%)

Results: bidders' profit & social welfare

	total bidders' profit		social welfare	
	lowcost	highcost	lowcost	highcost
Constant (Unr)	-13.36***	-26.90***	-27.12***	-59.02***
	(4.37)	(8.21)	(3.16)	(4.18)
Res	15.84***	6.38	2.04	12.05***
	(5.19)	(9.81)	(2.62)	(3.79)
Ind	8.623*	-12.92	5.40**	11.39***
	(5.20)	(9.81)	(2.62)	(3.78)
$v_1 - v_2$	0.91***	1.81***		
	(0.15)	(0.23)		
v_1			1.00***	0.95***
			(0.01)	(0.02)
Obs.	720	720	720	720
# of groups	72	72	72	72

Note: Model 1 and Model 2 are both panel regressions, while model 2 further controls for the difference of the highest value and the second-highest value in the group ($v_1 - v_2$)in bidders' profit and controls for the highest value in the group (v_1) in social welfare. Standard errors are in the parenthesis. *** Significant at the 1% level, ** at the 5% level, and * at the 10% level.

- Social welfare
  - *Ind* (*Res*) is higher (higher in high cost case) than *Unr*

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- Social welfare
  - *Ind* (*Res*) is higher (higher in high cost case) than *Unr*
- Bidder's profits
  - *Res* (*Ind*) is higher (weakly higher) than *Unr* in low cost case
  - *Res* is higher than *Ind* in high cost case

Conclusion

- *Ind* performs weakly better than Unr and strictly better than *Res* regardless of the entry cost
  - Social welfare higher than *Unr* and same as *Res*

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- Use of indicative messages deviate from predictions
  - Overuse of "2" in *Ind* leads to more participation and increases revenue while reducing bidder's profits
  - Entry choice mistakes exacerbate the impact of the inefficiency in selection in *Ind* and *Res*, lowering revenues.

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  - Social welfare higher than *Unr* and same as *Res*
- Use of indicative messages deviate from predictions
  - Overuse of "2" in *Ind* leads to more participation and increases revenue while reducing bidder's profits
  - Entry choice mistakes exacerbate the impact of the inefficiency in selection in *Ind* and *Res*, lowering revenues.
- Support for use of indicative bidding
  - Seller prefer Ind if cost of entry is uncertain
  - If implemented in a way that minimizes entry mistakes, this mechanism can be more effective
  - E.g. sequential expressions of interest

More Results: revenue regression

Table 3: Panel regressions on auction revenue

	Model 1		**Model 2**	
	low-cost	highcost	*low-cost*	highcost
Constant (Unr)	156.3***	107.1***	-10.28	-31.57***
	(5.74)	(7.44)	(7.21)	(10.53)
Res	-15.51*	-2.12	-13.90***	5.65
	(8.12)	(10.52)	(5.31)	(8.85)
Ind	-7.22	24.79**	-3.31	25.37***
	(8.12)	(10.52)	(5.31)	(8.84)
V_{2nd}			0.94***	0.84***
			(0.03)	(0.03)
Round			1.46**	0.24
			(0.71)	(1.02)
# of Obs.	720	720	720	720
# of Groups	72	72	72	72

Note: Both Model 1 and Model 2 use panel regressions, while model 2 further controls for the second-highest value in the group (V_{2nd}) and the time trend (i.e.Round). *** Significant at the 1% level, ** at the 5% level, and * at the 10% level.

Back

Measure two effects

$$PE^T = Rev(\alpha^T, Unr) - Rev(\alpha^{Unr}, Unr)$$

	c=5			c=25		
	Unr	**Res**	**Ind**	**Unr**	**Res**	**Ind**
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Measure two effects

$$SE^T = Rev(\alpha^T, T) - Rev(\alpha^T, Unr)$$

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Participation		5.15	8.00		9.49	9.49
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More Results: two effects

Table 4: Participation effect and selection effect

	Low-cost (c=5)				high-cost (c=25)			
	Res		Ind		Res		Ind	
	Obs.	**Pred.**	**Obs.**	**Pred.**	**Obs.**	**Pred.**	**Obs.**	**Pred.**
Participt.	2.85*	6.96	7.99	9.14	9.88	11.06	27.1***	6.28
	(43.67)	(34.99)	(57.80)	(40.42)	(80.38)	(43.49)	(91.43)	(32.14)
Selct.	-17.39***	-10.28	-13.73***	-4.83	-7.64***	-2.04	-7.28***	-2.15
	(20.92)	(9.87)	(19.10)	(6.23)	(17.04)	(4.33)	(14.31)	(4.60)

Note: Columns labeled "Obs." present the observed *participation effect* and *selection effect*. Columns "Pred." present the predicted effects, using the actual values drawn in the experiment and assuming participants all follow the equilibrium entry and bidding behaviors. Numbers in the round parentheses are the standard deviations. Asterisks next to the observed effect stands for the significance level of the t-test (clustered on the group level) comparing the observed effect to the equilibrium prediction. *** Significant at the 1% level, ** at the 5% level, and * at the 10% level.

Participation Selection

More Results: two effects regression

Table 5: Panel regressions: *participation effect* and *selection effect*

	Participation effect				Selection effect			
	Model 1		Model 2		Model 1		Model 2	
	low-cost	highcost	*low-cost*	highcost	lowhcost	highcost	*low-cost*	highcost
Res (Cons.)	2.85	9.88	-6.28	7.25	-17.39***	-7.64***	-12.34***	-5.09**
	(3.86)	(7.05)	(7.87)	(13.09)	(1.74)	(1.29)	(3.13)	(2.37)
Ind	5.13	17.22*	5.23	17.01*	3.65	0.36	3.55	0.58
	(5.46)	(9.97)	(5.47)	(10.05)	(2.46)	(1.82)	(2.48)	(1.81)
V_{2nd}			0.04	0.02			-0.04***	-0.03***
			(0.03)	(0.05)			(0.01)	(0.01)
Round			0.43	-0.21			0.37	0.26
			(0.80)	(1.33)			(0.30)	(0.24)
Obs.	480	480	480	480	480	480	480	480
Groups	48	48	48	48	48	48	48	48

Note: Model 1 and Model 2 are both panel regressions at the group level, while model 2 further controls for the second-highes value in the group (v_{2nd}) and the time trend variable "Round". Standard errors are in the parenthesis. *** Significant at th 1% level, ** at the 5% level, and * at the 10% level.

Participation Selection

More Results: revenue deviation

- Deviation from equilibrium in revenue contains two parts: Δ_{bid} and Δ_{entry}.

$$\underbrace{Observed - R_{pred}}_{\Delta_{total}} = \left(\underbrace{Observed - R_{bid_{NE}}}_{\Delta_{bid}}\right) + \left(\underbrace{R_{bid_{NE}} - R_{pred}}_{\Delta_{entry}}\right)$$

- R_{pred}: Expected revenue calculated by NE entry strategy and NE bidding strategy.
- $R_{bid_{NE}}$: Expected revenue calculated by the observed entry and selection results and NE bidding strategy.

More Results: Revenue deviation

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$$\underbrace{Observed - R_{pred}}_{\Delta_{total}} = \left(\underbrace{Observed - R_{bid_{NE}}}_{\Delta_{bid}}\right) + \left(\underbrace{R_{bid_{NE}} - R_{pred}}_{\Delta_{entry}}\right)$$

Table 6: Revenue decomposition

	Low cost			**High Cost**		
	UnR	**Re**	**Ind**	**UnR**	**Re**	**Ind**
Δ_{total}	2.32	-4.94	-0.98	5.30	0.15	25.04
Δ_{bid}	6.30	6.27	9.08	5.72	6.93	9.35
Δ_{entry}	-3.97	-11.21	-10.06	-0.43	-6.78	15.69

Literature

- Gentry and Stroup (2019, JFE)
  - Information bidders have prior to entry is neither zero nor perfect;
  - Information precision prior to entry varys from market to market.
- Li and Zhang (2015, AEJ Micro.)
  - Use timer sale auction in Oregon data show that private values are affiliated;
- Aradillas-López et al, (2013, Econometrica)
  - Positive correlation among bidders valuation.

Back