Endogenous entry in contests with incomplete information: Theory and experiments

Diego Aycinena  Lucas Rentschler

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In all-pay auctions we typically see a lot of expenditures close to zero, and a lot of very aggressive expenditures.

- Bimodal distribution of expenditures in complete information environments.
- Bifurcation in incomplete information environments.
- Usually, there is overexpenditure on average.
- Participants are often losing money.
- If there is an opportunity cost of entry, do we still see expenditures close to zero?
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- Independent private values.
- Endogenous participation.
- Opportunity cost of participation.

What is the effect of uncertainty regarding the number of contestants?

- Do entrants overexpend effort in such an environment?
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- Fu and Lu (2010), *Economic Inquiry*
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In this experiment we examine perfectly discriminating contests with independent private values and endogenous entry.

- The number of potential contestants is common knowledge.
- There is a positive opportunity cost of participating in the contest, which is common knowledge.
- When potential contestants decide whether or not to enter, they know both their value, and the opportunity cost.

We employ a $2 \times 1$ between subject design in which we vary whether or not the number of entrants is revealed when contestants choose their effort levels.
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6 sessions per treatment.

In each experimental session 12 subjects participated in a series of 25 periods.

Potential contestants were randomly and anonymously matched into groups of four in each period ($n = 4$).

We also elicited risk preferences (and varied the order).

Values were $iid$ draws from a uniform distribution on $[0, 100]$. ($F$)

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- Tic-tac-toe against the computer.
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- **Subjects were students at Universidad Francisco Marroquín.**
- Each session lasted about 1.5 hours.
- Each subject began with a starting balance of Q54 ≈ US$6.73 to cover any losses.
  - Participants were told that they could expend more than their remaining balance, but that if they went bankrupt they would not be paid for subsequent earnings.
  - No subjects went bankrupt.
- Each subject also received a participation fee of Q20 ≈ US$2.50.
- Average payoff: Q88.71 ≈ US$11.09.
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  - Min: Q39 ≈ US$4.88
  - Max: Q120 ≈ US$15
We consider symmetric Nash equilibrium.

Potential contestants only enter if their value is above some entry threshold in equilibrium.

This equilibrium entry threshold is the same regardless of whether or not the number of entrants will be revealed.

This threshold, \( v_c \), solves

\[
c = v_c F (v_c)^{n-1}
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Predictions

Entry

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\[ c = v_c F(v_c)^{n-1} \]
Predictions

Equilibrium effort

- Uninformed equilibrium effort:

\[ \beta (v_i) = \int_{v_c}^{v_i} t(n - 1) F(t)^{n-2} f(t) \, dt \]

- Informed equilibrium effort (\(m\) is the number of entrants):

\[ \rho (v_i) = \int_{v_c}^{v_i} t(m - 1) \left( \frac{F(t) - F(v_c)}{1 - F(v_c)} \right)^{m-2} \left( \frac{f(t)}{1 - F(v_c)} \right) \, dt \]
Predictions
Equilibrium effort

- Uninformed equilibrium effort:

\[ \beta(v_i) = \int_{v_c}^{v_i} \frac{v_i}{(n - 1) F(t)^{n-2} f(t)} dt \]

- Informed equilibrium effort (\(m\) is the number of entrants):

\[ \rho(v_i) = \int_{v_c}^{v_i} \frac{v_i}{t (m - 1) \left( \frac{F(t) - F(v_c)}{1 - F(v_c)} \right)^{m-2} \left( \frac{f(t)}{1 - F(v_c)} \right)} dt \]
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Predictions
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Expected total effort expenditure is the same regardless of whether the contestants know $m$ when they choose their effort levels.

$$R = n(n - 1) \int_{v_c}^{\bar{v}} (1 - F(t)) tF(t)^{n-2} f(t) dt$$
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Endogenous entry in contests

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Entry

\[ \begin{array}{cccccc}
-0.2 & 0 & 0.2 & 0.4 & 0.6 \\
\end{array} \]

Observed over-entry

\[ \begin{array}{cccccc}
0 & 5 & 10 & 15 & 20 & 25 \\
\end{array} \]

Period #

Informed Uninformed

\[ \begin{array}{c}
\text{Informed} \\
\text{Uninformed}
\end{array} \]
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Observed entry decision relative to prediction

Region 1

Region 2

Uninformed

Informed

Non-entry (correct)

Entry (correct)

Under-entry (incorrect)

Over-entry (incorrect)
Entry
Relative to Nash

Entry relative to Nash predictions

<table>
<thead>
<tr>
<th>Condition</th>
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<tbody>
<tr>
<td>$v_i &lt; v_c$, uninformed</td>
<td>0.303</td>
</tr>
<tr>
<td>$v_i \geq v_c$, uninformed</td>
<td>0.738</td>
</tr>
<tr>
<td>$v_i &lt; v_c$, informed</td>
<td>0.365</td>
</tr>
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- Entry is higher than predicted.
  - Uninformed: Sign test, $p = 0.0156$
  - Informed: Sign test, $p = 0.0156$

- Entry is higher when contestants are informed.
  - Robust rank order test, $p < 0.01$
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Payoffs

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<table>
<thead>
<tr>
<th>Value</th>
<th>Profit</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>0</td>
</tr>
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Uninformed

Informed
Payoffs

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Payoff of bidders net of the outside option

Value

Uninformed

Informed
Payoffs

- Payoffs are lower than predicted.
  - Uninformed: Sign test, $p = 0.0156$
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- Payoffs are higher when contestants are uninformed.
  - Robust rank order test, $p = 0.029$

- Payoffs of entrants are less than the opportunity costs.
  - Uninformed: Sign test, $p = 0.0156$
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Effort expenditure

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Effort expenditure

- Effort expenditures are higher than predicted.
  - Uninformed: Sign test, $p = 0.0156$
  - Informed: Sign test, $p = 0.0156$
- We can’t reject that effort expenditures are equal across information structures.
  - Robust rank order test, $p = 0.22542$
Effort expenditures are higher than predicted.

- Uninformed: Sign test, $p = 0.0156$
- Informed: Sign test, $p = 0.0156$

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  - Robust rank order test, $p = 0.22542$
Total expenditure is higher than predicted.

- Uninformed: Sign test, $p = 0.0156$
- Informed: Sign test, $p = 0.0156$

Total expenditure is higher when contestants are informed.

- Robust rank order test, $p = 0.01234$
- Total expenditure is higher than predicted.
  - Uninformed: Sign test, $p = 0.0156$
  - Informed: Sign test, $p = 0.0156$
- Total expenditure is higher when contestants are informed.
  - Robust rank order test, $p = 0.0123$
Total expenditure is higher than predicted.

- Uninformed: Sign test, $p = 0.0156$
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Total expenditure

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Efficiency

- $v_{\text{winner}} =$ the value of the contest winner.
- $v_{\text{max}} =$ the value of the contestant with the highest value.
- $v_{\text{min}} =$ the value of the contestant with the lowest value.

Allocative efficiency

\[
\frac{v_{\text{winner}}}{v_{\text{max}}}
\]

Total efficiency

\[
\frac{(v_{\text{winner}} - mc) - (\min(v_{\text{min}} - nc, 0))}{\max(v_{\text{max}} - c, 0) - (\min(v_{\text{min}} - nc, 0))}
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Efficiency

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- Allocative efficiency

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\frac{v_{\text{winner}}}{v_{\text{max}}}
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Allocative efficiency

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Total efficiency

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Allocative efficiency is lower than predicted when contestants are informed.

- Sign test, $p = 0.0156$
- We can’t reject that allocative efficiency is equal to its prediction when contestants are uninformed.
  - Sign test, $p = 0.1094$
- We can’t reject that allocative efficiency is equal between information structures.
  - Robust rank order test, $p = 0.14373$
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  - This is the opposite of the result for first-price auctions.
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- We still see a lot of effort choices close to zero.

Entering in the hopes of winning with an effort of zero?
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Conclusion
Summary of results

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