Dueling Contests and Platform's Coordinating Role*

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* Paper available at www.stouras.com and under review.

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What is an (innovation) contest?

$$(\alpha_1, \alpha_2, \ldots, \alpha_n)$$

Objective:

Maximize the *best* solution

from the crowd

Monopolistic (Standalone) Contest

An innovation contest is a paradigm in which a firm seeks to advance its technology by sourcing ideas from a crowd competing for prizes

What is an (innovation) contest?

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from the crowd

Monopolistic (Standalone) Contest

$(\alpha_1, \alpha_2, \ldots, \alpha_n)$ $(\beta_1, \beta_2, \ldots, \beta_n)$

Objective:

Maximize the *best* submitted solution

from the crowd

Dueling Contests on a Platform

Reward allocation is a way to differentiate from a competitor

Platforms host multiple concurrent contests

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AstraZeneca

Smart Prediction for Cardiac Pathology   Featured

Deadline: **Under Eval** | Active Solvers: 228

Tags: AstraZeneca, Computer Science/Information Technology, Life Sciences, Theoretical-licensing

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Grünenthal Challenge: Repurposing Drugs for Pain Treatment   Featured

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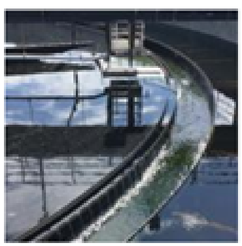

Pathogen Monitoring Challenge – Stage 1

Deadline: **Under Eval** | Active Solvers: 132

Tags: Business/Entrepreneurship, Chemistry, Computer Science/Information Technology, Engineering/Design, Environment, Global Health, Life Sciences, Public Good, Water, Theoretical

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SUDEP INSTITUTE

The SUDEP Institute Challenge: Developing Predictive Biomarkers of SUDEP

Deadline: **Oct 10 2020 23:59 EDT** | Active Solvers: 334

Tags: Global Health, Life Sciences, Royal Society of Chemistry, RTP

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Whether to promote certain contests

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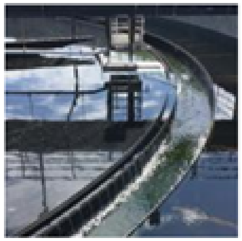

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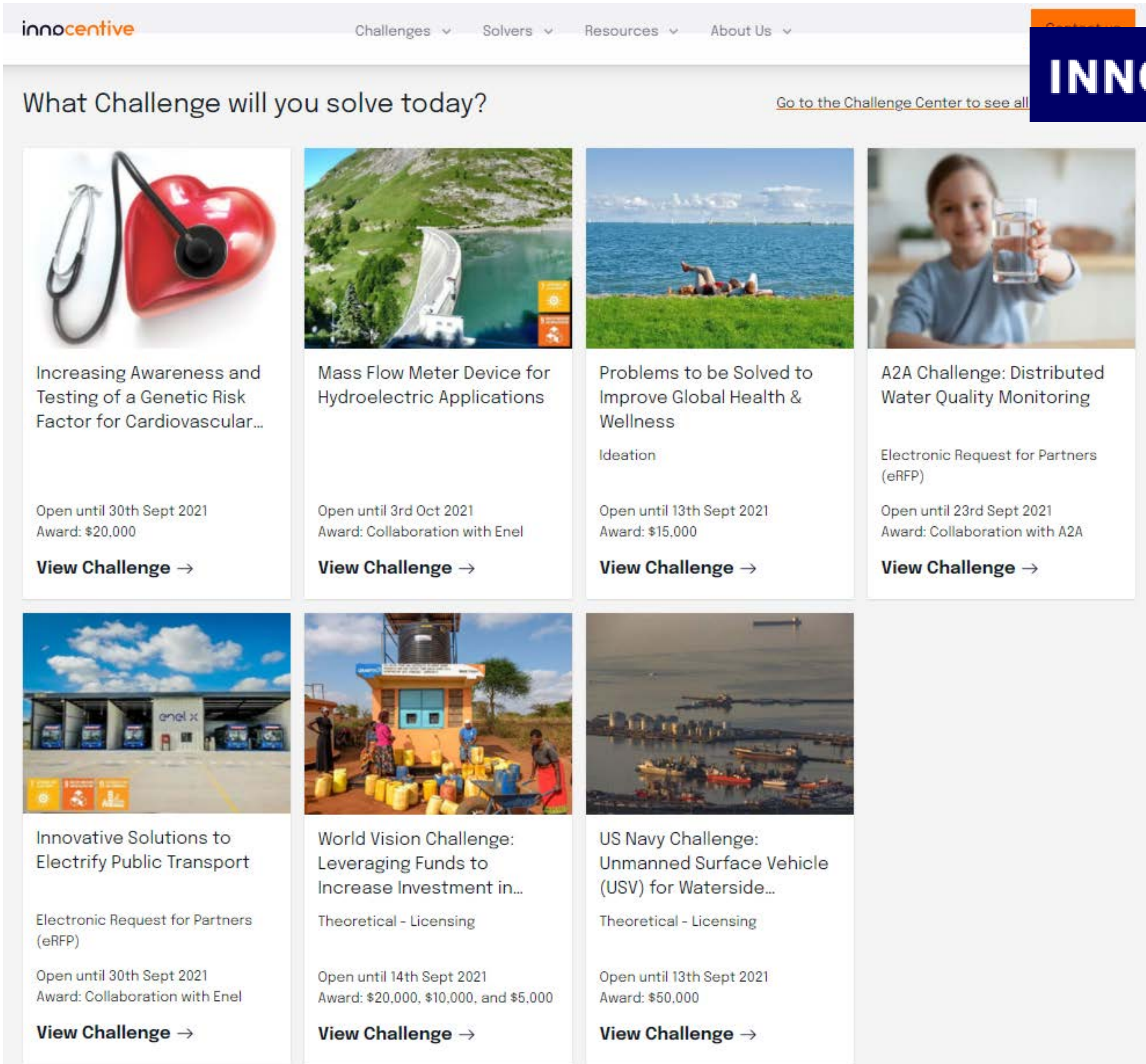
Featured contests appear on top



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Research questions

Solvers: Which contest to participate and exert effort?

Firms: How to design a contest in the presence of competing firms that host their contests in parallel?

Platform's coordinating role:

- Welfare-optimal budgets?
- Do "featured contests" maximize welfare?
- Matching solvers to contests?

What do we know about this problem?

Monopolistic contest design (in OM)

Kalra and Shi (2001); Terwiesch and Xu (2008); Bimbikis, Ehsani and Mostagir (2017); Ales, Cho and Körpeoğlu (2017); Mihm and Schlapp (2018); Chen, Mihm and Schlapp (2021); Körpeoğlu, Korpeoglu and Hafalir (2022); Moghadas, Nittala and Krishnan (2022); **… ++**

Monopolistic contest design with (partial) entry

Erat and Krishnan (2012); Stouras, Hutchison-Krupat and Chao (2021)

Competing auctions and competing contests (in Econ/CS):

McAfee (1993); Peters and Severinov (1997); Virag (2010); Ashlagi, Monderer and Tennenholtz (2011); Azmat and Möller (2009); DiPalantino and Vojnovic (2009)

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Two (known) major impediments:

(1) *infinite regress*: large space of mechanisms, e.g. a mechanism of one may depend on the announced mechanism of the other in general.

(2) *No Analog to the Revelation Principle*, i.e. no tool to abstract away from strategic buyers and sellers' equilibrium depends on buyers' induced equilibrium.

In short: Not much! And it's a hard problem for general cases

A simple example: Competing ideation contests

Firm a

Solution quality $\sim G(\cdot)$

Budget: $b_1 \geq b_2$

Prize allocation: $(\alpha, 1-\alpha, 0, 0)\,,\ \alpha \in \left[\frac{1}{2}, 1\right]$

Firm b

Solution quality $\sim G(\cdot)$

Budget: b_2

Prize allocation: $(\beta, 1-\beta, 0, 0)\,,\ \beta \in \left[\frac{1}{2}, 1\right]$

4 solvers: Participation?

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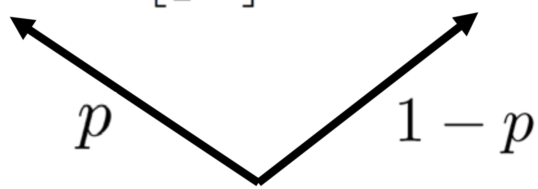

4 solvers: Participation?

Expected utility in A = Expected utility in B

$$(1-p)^3 \cdot \alpha + 3(1-p)^2 \cdot p \cdot \frac{1}{2} + 3(1-p) \cdot p^2 \cdot \frac{1}{3} + p^3 \frac{1}{4} = p^3 \cdot \beta + 3(1-p) \cdot p^2 \cdot \frac{1}{2} + 3(1-p)^2 \cdot p \cdot \frac{1}{3} + (1-p)^3 \frac{1}{4}$$

p: entry probability into firm a

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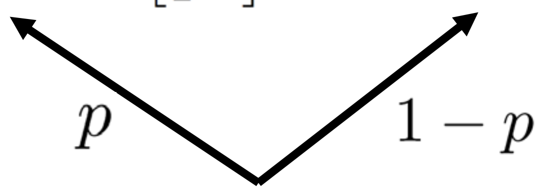

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Entry probability in firm a strictly increases in α (for *any* β!)

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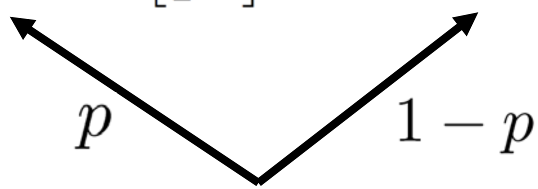

4 solvers: Participation?

Best *participating* solution in firm a:

$$\pi_a(\alpha;\ \beta) = \sum_{k=1}^{4} \binom{4}{k} p^*(\alpha;\ \beta)^k \left(1 - p^*(\alpha;\ \beta)\right)^{4-k} \cdot \mathbb{E}\left[\max_{1\leq i\leq k} Z_i \,\middle|\, N_a = k\right]$$

Exp. Best Noise cond. k entrants
(strictly increases in k)

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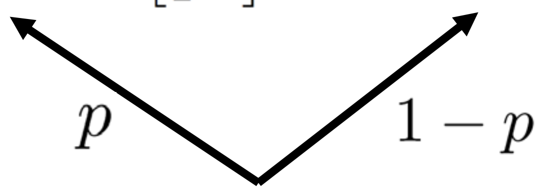

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$$\pi_a(\alpha;\, \beta) = \sum_{k=1}^{4} \begin{pmatrix} 4 \\ k \end{pmatrix} p^*(\alpha;\, \beta)^k \left(1 - p^*(\alpha;\, \beta)\right)^{4-k} \cdot \mathbb{E}\left[\max_{1 \leq i \leq k} Z_i \,\middle|\, N_a = k\right]$$

Firm a's objective strictly increases in *p* (which increases in the 1st prize, *α*)

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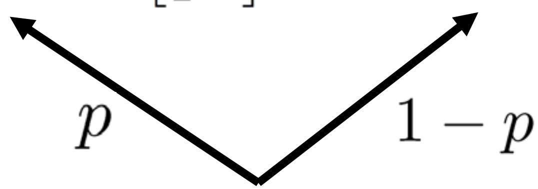

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α*=1: WTA is a (strictly) dominant strategy for firm a

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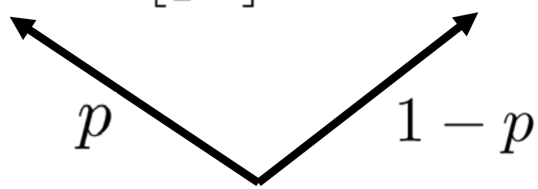


4 solvers: Participation?

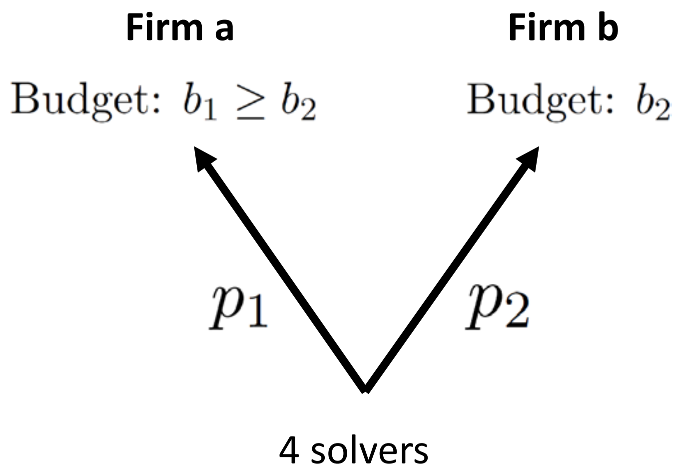
Key take-aways:

(WTA, WTA) is the unique (pure) equilibrium reward allocation!

A single WTA prize maximizes participation in purely noise-driven contests

$$p \in \left(\frac{1}{2}, 1\right)$$

Platform: Firm-level coordination
Restricting firms' budgets at the outset



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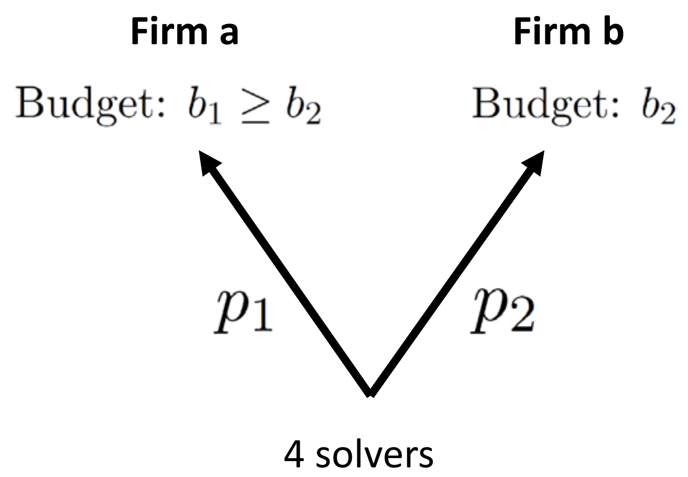

Introducing the **effective noise distribution**:

$$G_j\left(z;\, p_j\right) := 1 - p_j + p_j \cdot G\left(z\right)$$

Not entering

Entering with lower noise than z

Platform: Firm-level coordination
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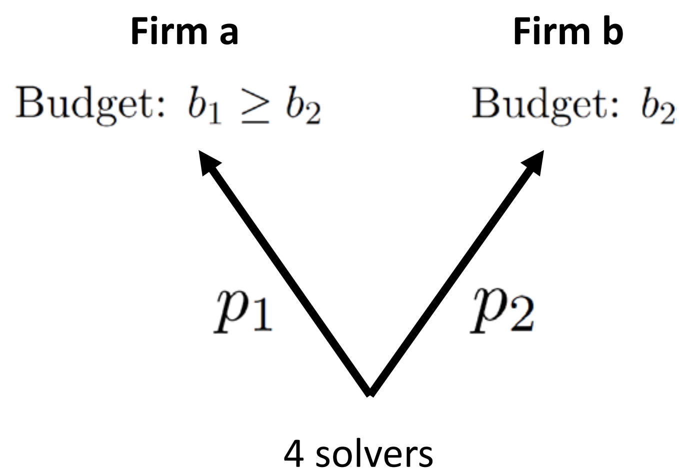

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Not entering

Entering with lower noise than z

Treating a non-entrant as an “entrant” that loses with certainty, we keep the number of entrants *fixed* at *n* irrespective of entry probabilities.

Platform: Firm-level coordination
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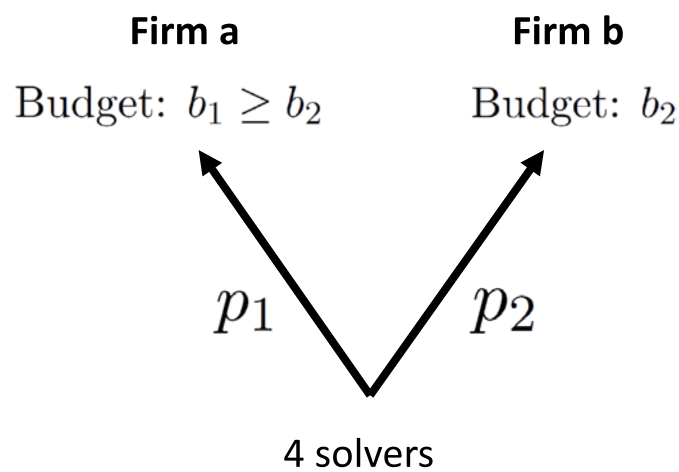

Stochastic orders:

$$G(z) \leq G_j(z; p_j)$$

Presence of Firm 2 makes Firm 1 receive a worse distribution of ideas [trivial]

Platform: Firm-level coordination
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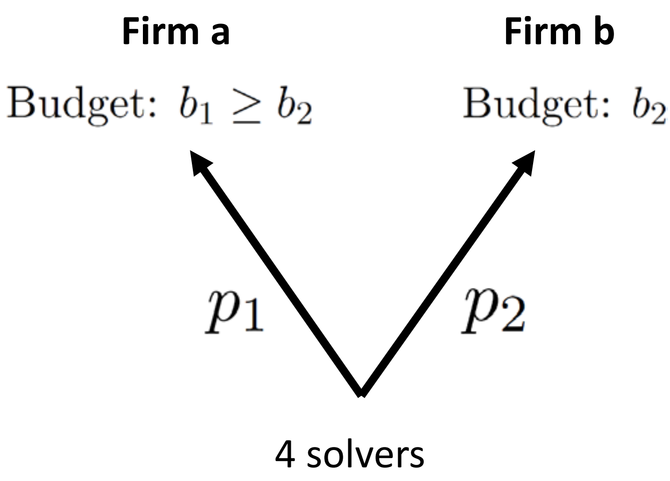
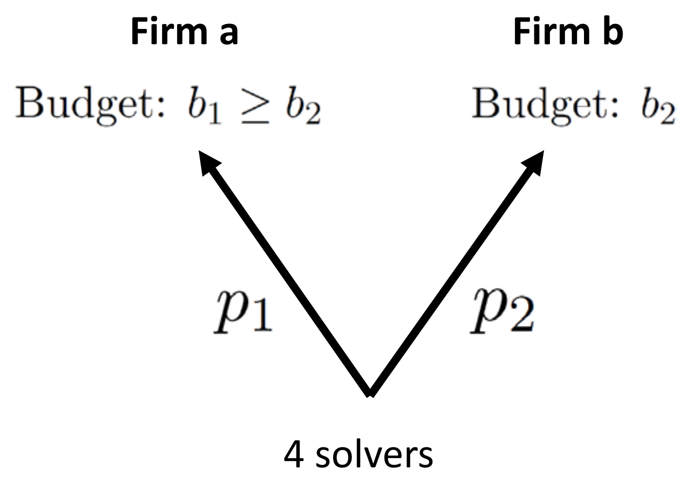


Stochastic orders:

$$G_1(z; p_1) < \boxed{G^*\left(z; \tfrac{1}{2}\right)} < G_2(z; p_2)$$

Submitted ideas
under equal budgets

Platform: Firm-level coordination
Restricting firms' budgets at the outset



Stochastic orders:

$$G_1(z; p_1) < G^*\left(z; \tfrac{1}{2}\right) < G_2(z; p_2)$$

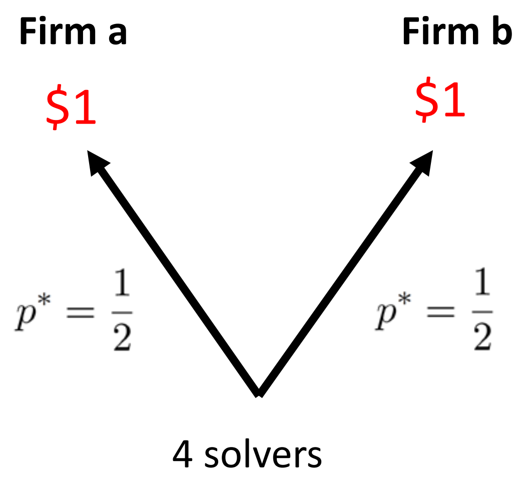
+

Concavity wrt p1:

$$\pi(p_1) := \pi_{\text{duo},1}(p_1) + \pi_{\text{duo},2}(1 - p_1)$$

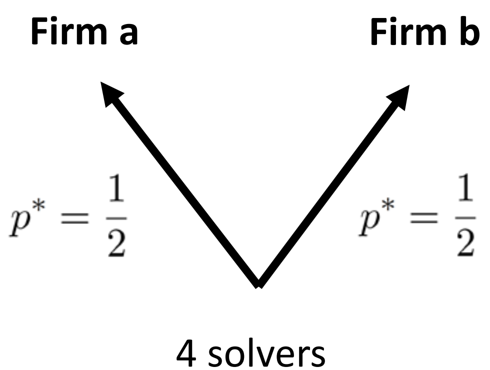
Aggregate welfare
(i.e. total firms' profits and total solvers payoffs)

Platform: Firm-level coordination
Restricting firms' budgets at the outset

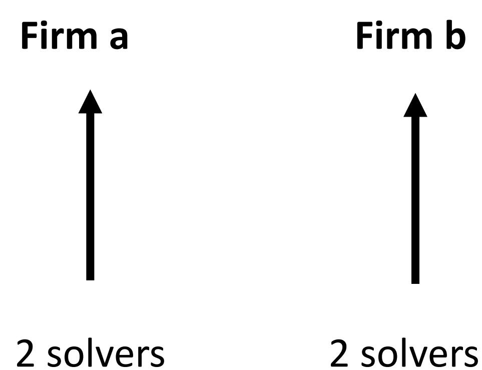


Contests with homogeneous budgets strictly improve aggregate welfare

Platform: Solver-level coordination
Nudging solvers into contests



vs.



Blind entry

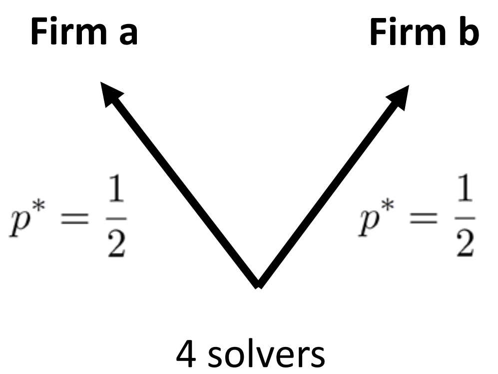
Solvers self-select a contest to participate

Nudged entry

Platform recommends a contest to each solver and solvers follow the nudge

Are solvers and firms hurt by “featured contests” that nudge solvers?

Nudging solvers into contests



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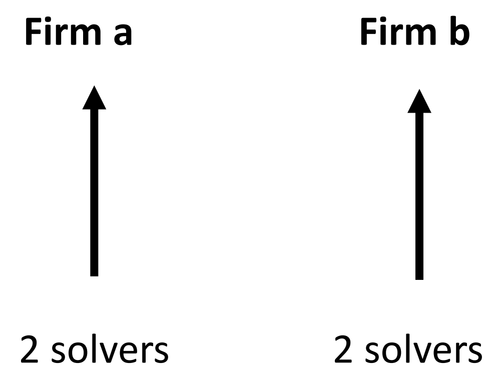


Blind entry

Nudged entry

Solvers:

$$u^* = \sum_{k=1}^{4} \binom{3}{k-1} (p^*)^{k-1} (1-p^*)^{4-k} \cdot \frac{1}{k}$$

$$\overset{p^*=\frac{1}{2}}{=} \frac{15}{32}$$

$$< \frac{1}{2}$$

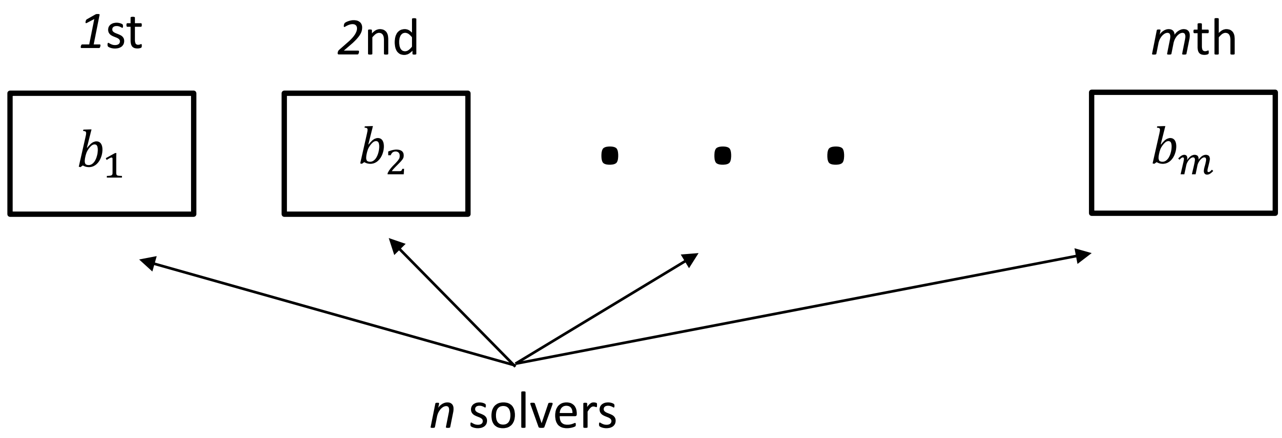
Solvers:

1/2 in each contest

Theorem [Nudging]

Nudged entry benefits the firms, the solvers and the platform.

Summary of the Paper

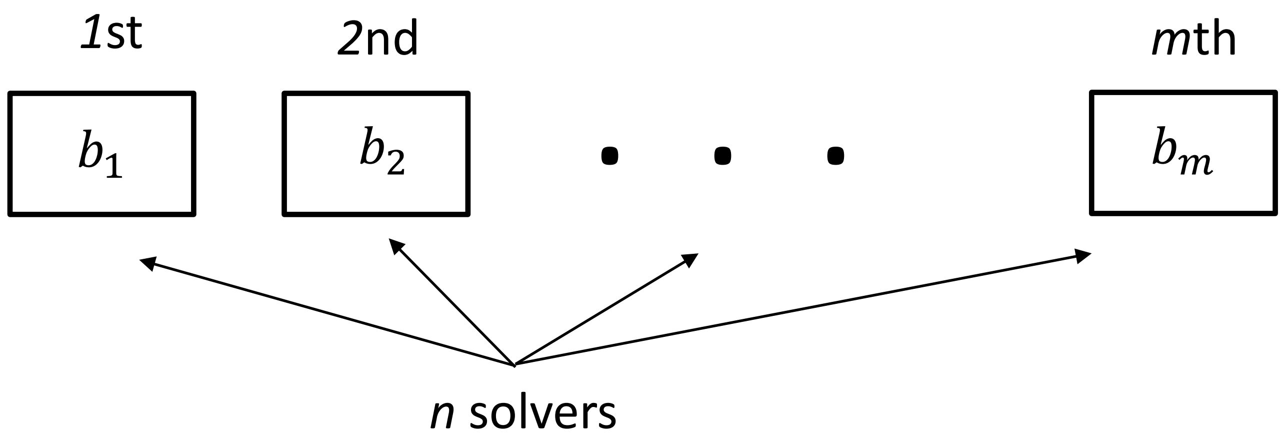


Solver *i*'s output in contest *j* is both driven by effort and randomness to some extent:

$$X_{ij} = Z_{ij} \cdot (e_{ij})^{\vartheta}, \ \vartheta \geq 0$$

Sensitivity parameter

Summary of the Paper



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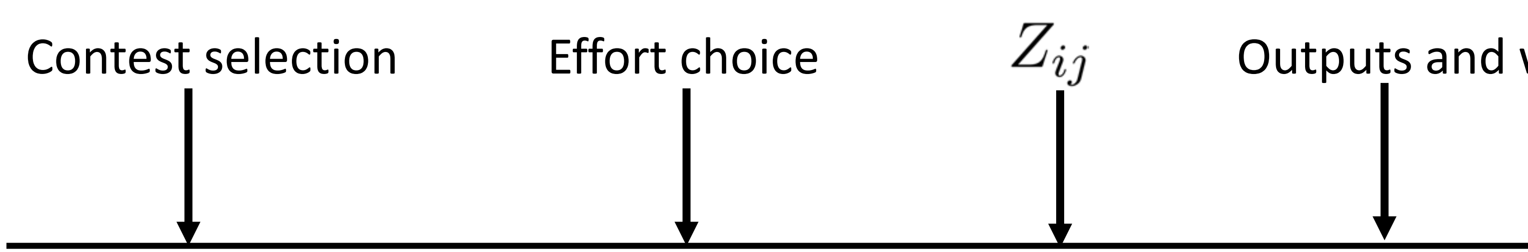
Noise = Known *ex-post* effort, **noise-driven contests**



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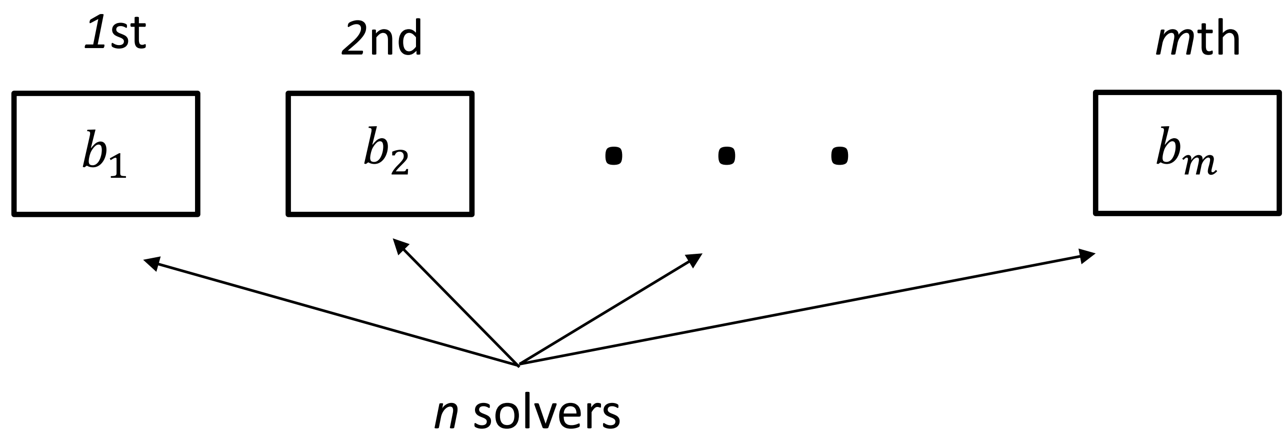

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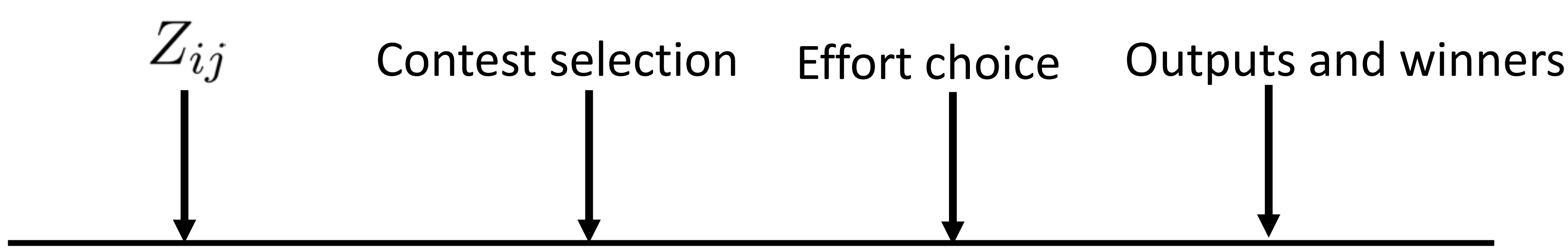
Ability = Known *ex-ante* before entering, **ability-driven contests**



Noise-driven contests

Proposition 1 [Monopoly, i.e. solvers' effort optimization only]

Multiple prizes of *equal* size are optimal in general (depending on the *noise distribution*).

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Proposition 2 [Oligopolistic equilibrium in prize allocations]

Existence of symmetric (firm-level) equilibrium:

Multiple prizes of *equal* size in general (depending on the *noise distribution* and θ but *not on firms' budgets*).

Weakly fewer (and larger) equally-sized prizes compared to monopoly.

For all noise distributions, (WTA, WTA, …, WTA) is the unique equilibrium in allocations for purely noise-driven contests (i.e. $\theta=0$).

Noise-driven contests

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Corollary

For all noise distributions, WTA is "approximately optimal" for "sufficiently" noise-driven contests (*irrespective of the characteristics of a firm's competitors*).

Allocating a single WTA prize is approximately optimal

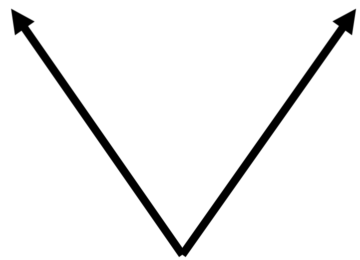
Ability-driven contests

Firm a (WTA)

Budget: $b_1 \geq b_2$

Firm b (WTA)

Budget: b_2



Private contest-dependent abilities of solver i: $\boldsymbol{a}_i := (a_{i1}, a_{i2}) \in [0,1]^2$

$F(\cdot,\cdot)$ (atomless and commonly known)

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We allow contest abilities to be arbitrarily correlated (per solver)

Q: Which contest would you enter given your skills and your beliefs of skills of others?

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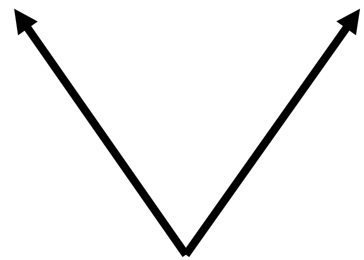

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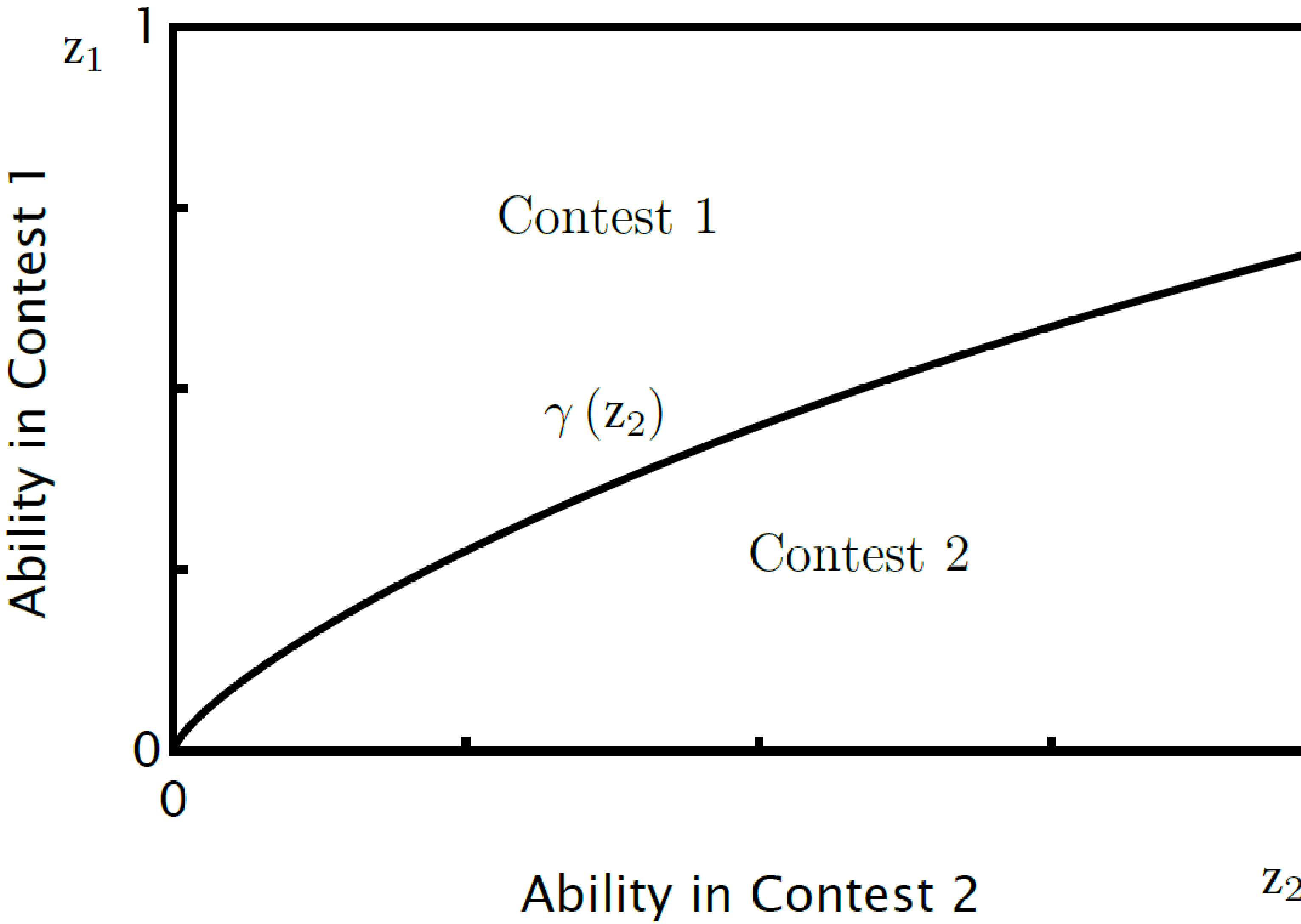
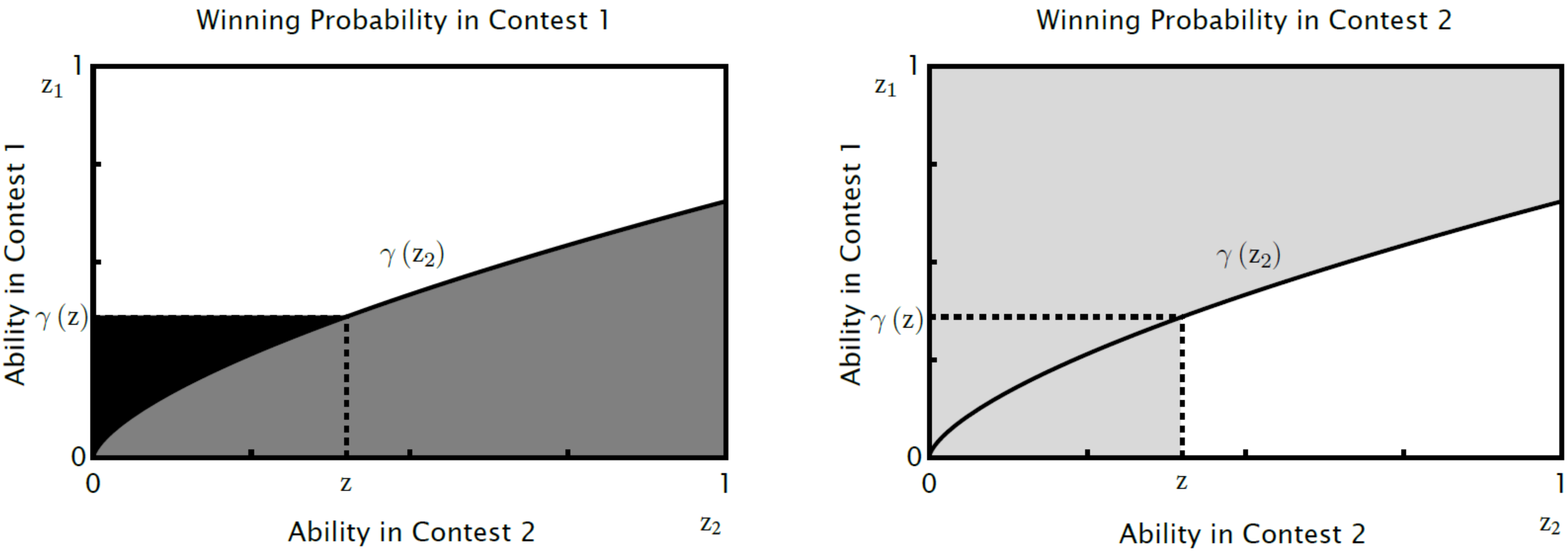
A: If budgets are equal: max ability [trivial]
Unequal budgets?

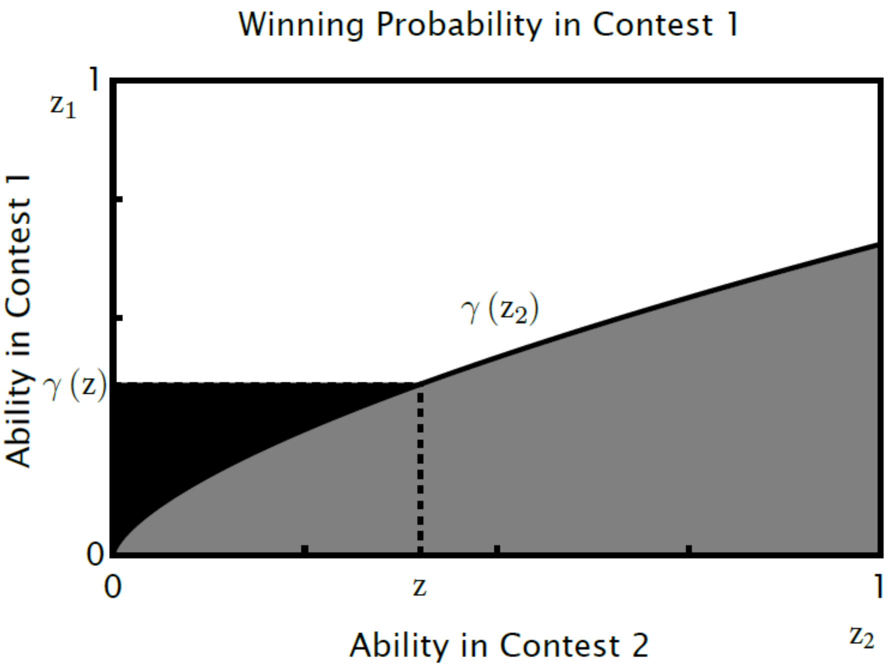
Unequal budgets and ability-driven contests

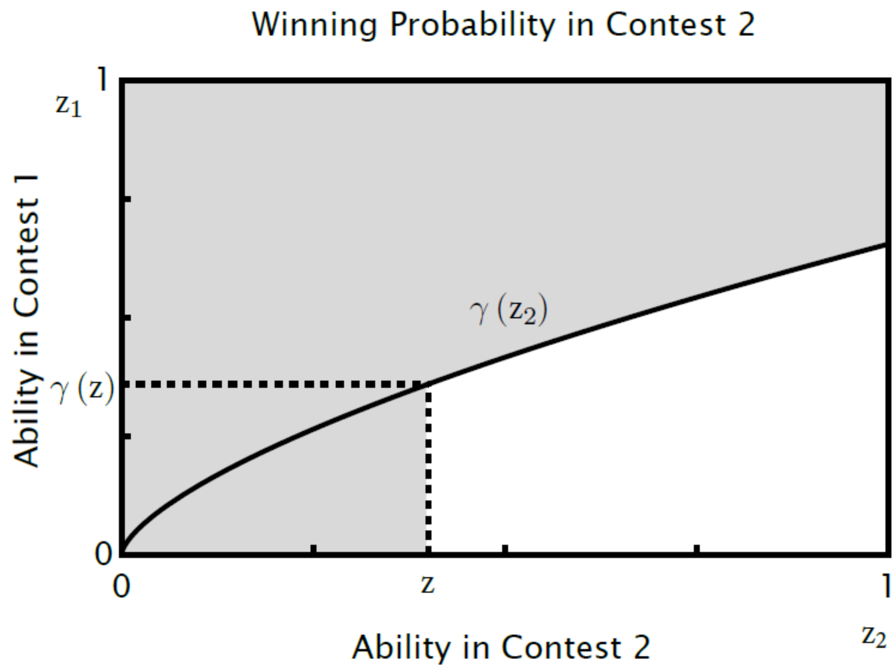


Unequal budgets and ability-driven contests



Unequal budgets and ability-driven contests

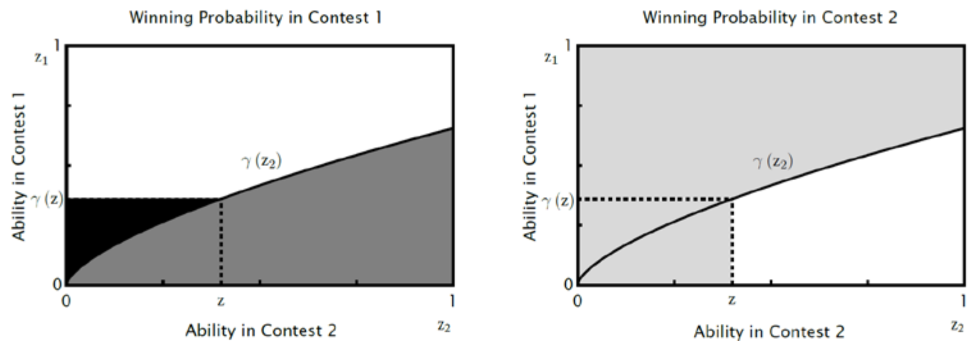




$$w_1(z) = \int_0^z \int_0^{\gamma(z)} f(t_1, t_2)\, dt_1 dt_2 + \int_z^1 \int_0^{\gamma(t_2)} f(t_1, t_2)\, dt_1 dt_2$$

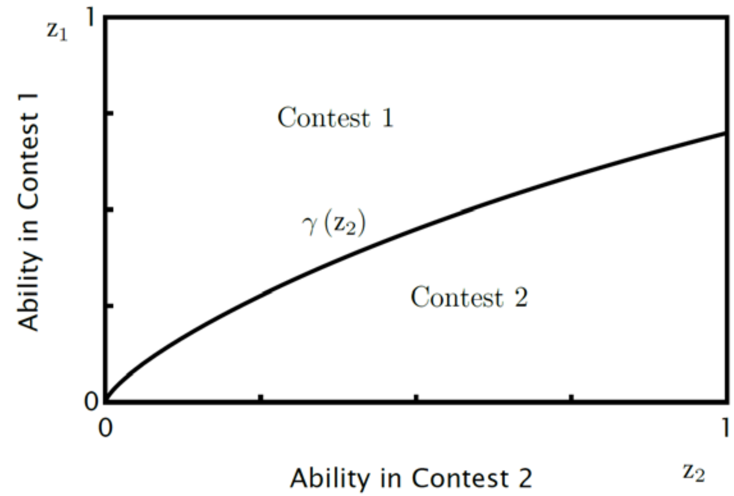
$$w_2(z) = 1 - \int_z^1 \int_0^{\gamma(t_2)} f(t_1, t_2)\, dt_1 dt_2$$

Unequal budgets and ability-driven contests



$$b_1 w_1 (z)^{n-1} = b_2 w_2 (z)^{n-1}$$

Unequal budgets and ability-driven contests



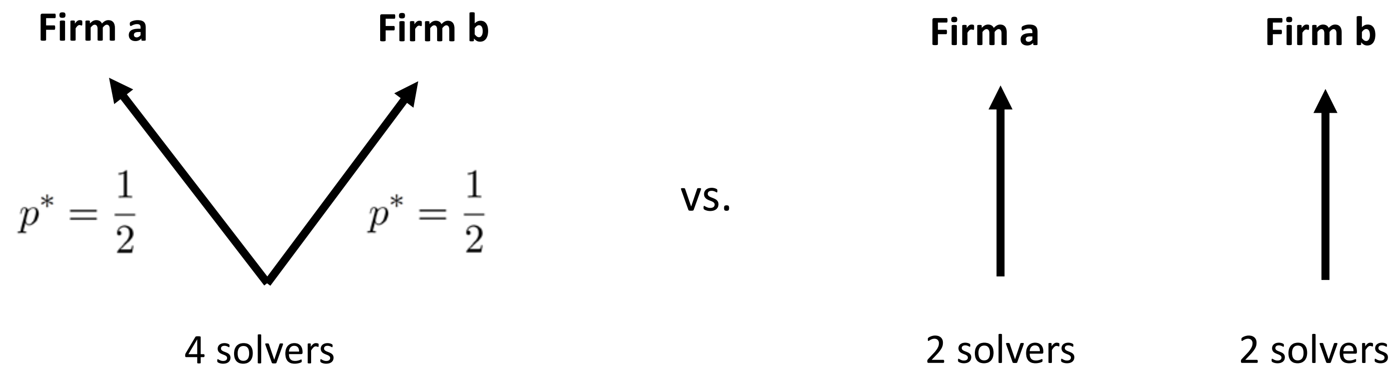
Theorem [Solvers' contest selection in a duopoly of ability-driven contests]

An (essentially) unique symmetric equilibrium, where the γ(.) boundary is the solution to the functional integro-differential equation

$$\gamma'(z) \cdot \int_0^z f(\gamma(z), t_2)\, dt_2 = \phi \cdot \int_0^{\gamma(z)} f(t_1, z)\, dt_1 \qquad \gamma(1) = \phi := \left(\frac{b_2}{b_1}\right)^{\frac{1}{n-1}}$$

No closed-form solution, but structural properties.
Changing your contest shifts the entire boundary of types.

Nudging heterog. solvers to heterog. contests



Blind entry

Solvers self-select a contest to participate

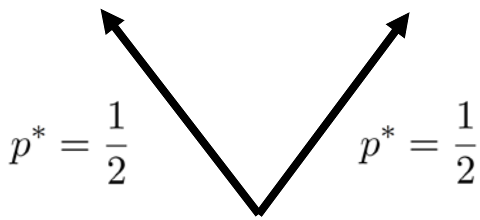
Nudged entry

Platform recommends a contest to each solver and solvers follow the nudge

Q: Are solvers and firms hurt by “featured contests” that nudge solvers?

Q: Is nudging heterog. solvers to heterog. contests welfare-optimal?

Firm a Firm b



4 solvers

Blind entry

Solvers self-select a contest to participate

vs.

Firm a Firm b

2 solvers 2 solvers

Nudged entry

Platform recommends a contest to each solver and solvers follow the nudge

Theorem

Nudging solvers to contests strictly improves welfare, if solver abilities are sufficiently correlated across contests.

Platform insight: Nudge solvers to contests if contest skills are suff. (positively) dependent. Let solvers self-select contests otherwise.

Implications for contests on platforms*

- Solver-level decision-making:
  - How to allocate resources in the face of “endogenous” outside options?
- Firm-level decision-making:
  - Be aware of your competitors
  - How does your objective position you compared to them?
- Platform-level decision-making:
  - Regulating the firms (budget) and restricting solvers’ contest entry through “featured” contests or other nudging mechanisms is welfare optimal

* Paper available at stouras.com and under review (Minor Revision, Mgmt Sc, Rev Mgmt Area).
Preliminary version accepted at the *Proceedings of the 21st ACM Conference on Economics and Computation (EC), 2020.*

Follow-up projects

- "*Momentum Equilibria in Participation on Platforms: Implications for Inequity*", joint with **Sanjiv Erat (UCSD)** and **Jeeva Somasundaram (IE)**
  - Lab experiment to sustain continued participation on a platform and mitigate worker inequity (under review)

- "*Competing screening contests*", joint with Mobin Nejati (UCI Student)
  - How to screen applicants in the face of a competitor who screens as well?

- "*The focused platform*" (with efood.gr)
  - The "optimal" level of diversity a platform should maintain on the buyer and seller side.

Theory and Experiments on **crowdsourcing** and **platform design**,
and applications in innovation, services, transportation and retail.