Contest Partitioning in Binary Contests: Costly, yet Beneficial

JAAMAS Track

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ABSTRACT

In this work we present the idea of partitioning contestants into disjoint groups, each competing in an independent contest, with its own prize. We focus on binary contests, wherein contestants choose whether or not to participate, and show that such contest partitioning can benefit the organizer running the contest when partitioning entails a cost.

KEYWORDS

Multi-agent systems; Contest design; Mechanism design

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1 INTRODUCTION

The literature on contest theory has largely focused on contests wherein all contestants compete with each other for the same prize (or set of prizes). This is also true for tournaments, where contests are carried out in stages [7, 27, 28], but all competitors ultimately compete for the same reward. However, in many real-world settings, there is no requirement that all potential contestants participate in one single contest. Instead, the contest organizer can carry out several completely separated contests, in terms of the prizes awarded and winners determination rules, assigning different contestants to disparate contests. Meanwhile, the organizer can still benefit from the aggregate work conducted in all the disparate contests. For example, consider running a hackathon with the goal of finding a solution to a specific problem. Here, the goal of the organizer is to maximize the quality of the best solution developed. Rather than running one "grand hackathon", the organizer can run several smaller hackathons (possibly taking place at different locations), each declaring its own winner and awarding a separate prize. The organizer would still benefit from the best solution obtained among all the different hackathons

Can such contest partitioning benefit the organizer? Can it increase her expected profit? Prior works attempting to answer these questions have focused on effort-based contests (where contestants decide the *amount* of effort they exert) and offer partial and mixed conclusions. Most of these works are based on restricted models, which are limited in the number of contests (typically two) used, prospective contestants, prizes, and the partition flexibility of the organizer [1, 2, 8, 12, 16]. Other works allow for more tractable partitioning [3, 6, 14], finding that the dominance relation (between a grand and partitioned contest) depends on the contest characteristics, such as the winner-determination protocol, level of randomness, and number of contestants. These works are limited by the fact that they take the sum of prizes to be awarded as equal to the original prize assigned to the grand contest, rather than optimizing each sub-contest independently. Most importantly, all the above works have neglected partitioning cost, which is the primary constraining cost of the optimal partitioning.

This abstract focuses on the *binary contest* model, wherein contestants only decide whether or not to participate, while the quality of their submissions is determined endogenously. This model captures settings where the quality of the submission does not depend on effort, such as beauty contests, or where contestants' evaluation is based on activities that took place before the contest, such as in a lifetime achievement award. Consider, for example, an award nomination. Here, contestants only strategize on whether to apply or not, without having a chance to further enrich their (past) achievements at the time of nomination. Here, the choice to participate is not straightforward, as there is a cost associated with participating, such as a reputational loss in the case of not winning a prestigious award. Many previous works have studied this model [4, 9–11, 13, 15, 17, 19–26, 29, 30].

2 RELATED WORK

While most prior work studying contest design relies on a model of a single grand contest, some literature does consider parallel contest designs where the organizer benefits from some aggregation of all contributions [2, 8, 12, 16]. The models used in these studies are quite degenerate in terms of number of contests (typically two), number of prospective contestants, the prizes used and the partition flexibility of the contest designer. While these studies compare the choice between a single contest and multiple contests (from the agents' and organizer's point of view) based on the prize structure, none of them has analyzed the optimal partition to multiple sub-contests, as in this work. Furthermore, none of the models used consider contest partitioning costs.

Very few works provide general theoretical results on optimal partitioning into multiple sub-contests, all relying on the effort-based contest model [3, 5, 6, 14]. The models used in these works assume that the sum of prizes is given and fixed, i.e., the sum of prizes allocated to the sub-contests equals to the original prize assigned to the grand contest, meaning that the sub-contents used are not optimized. Furthermore, they all assume there is no additional

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cost for the organizer to running more (sub-)contests. Our work, which is an extended abstract of [18], allows the organizer to adjust the prize amounts to the sub-contests and consider partitioning costs. This change turns to be instrumental, as the advantage in contest partitioning derives from the ability to maintain similar performance level while reducing the amount allocated as prizes.

3 MODEL AND PRELIMINARIES

Binary Contests. The model stipulates a contest organizer and a set $A = \{A_1, ..., A_k\}$ of fully-rational and self-interested agents (the potential contestants). Each agent decides whether or not to participate in the contest. Participation incurs a cost c. To encourage participation, the organizer offers a prize $M \geq c$, awarded to the agent with the highest *contribution quality* among participating agents (with a random tie breaking rule). Agent A_i's contribution quality value, denoted q_i, is drawn from a probability distribution function $f(\cdot)$ (with $F(\cdot)$ being the corresponding CDF), where f is assumed to be identical for all agents, and is common knowledge among the organizer and all agents. Agents are assumed to know their own actual quality of contribution before making their participation decision, but not that of the other agents. The organizer only knows f. The goal of each agent is to maximize its expected profit, defined as the expectation of the prize received minus the cost c incurred if participating. The organizer's goal is to maximize her total profit, defined as her utility from the agents' qualities minus the prize she pays. The utility the organizer derives from the agents' qualities is defined by an aggregation function, g, over the qualities of the participating agents (e.g., sum/max). If none of the agents participates, the prize is not awarded and the organizer's utility is assumed to be zero. Formally, a *binary contest* is a quintuple $C = (A, M, f, c, g)$, where the components are as defined above.

Contest Partitioning. The above standard model is extended to accommodate contest partitioning. In a *partitioned contest* the agents are partitioned into $n \leq k$ disjoint subsets $D_1, \ldots, D_n$, $|D_i| > 1$ for all i. Each D_i defines a sub-contest, with the agents thereof competing amongst themselves, and the best awarded the prize M_i. An agent assigned to sub-contest D_i can decide whether or not to participate in this sub-contest, but cannot participate in any other sub-contest. The participation cost, c, and quality distribution, f, remain as in the basic model. Importantly, the aggregation function, g, also remains as in the basic model; that is, the utility of the organizer is obtained from the aggregate qualities of all agents in all contests. Partitioning a contest may entail a cost. We stipulate a price c_p associated with each partitioning of the contest into smaller sub-contests; the partitioning cost c_p represents the cost associated with running separate contests. In all, if the contest is partitioned into n sub-contests, then the total partitioning cost is $(n-1)c_p$.

The organizer's goal is to maximize her total profit, defined as the aggregate function over the qualities of all participating agents, minus the sum of the prizes awarded and the partitioning costs incurred. Formally, a *partitioned contest* is a sextuple $P = (\mathcal{A}, \mathcal{M}, f, c, g, c_p)$, where $\mathcal{A} = (D_1, \ldots, D_n)$ is the partition structure, $\mathcal{M} = (M_1, \ldots, M_n)$ is the prize sequence, f, c, g, as in the regular model, and c_p is the partitioning cost. Each $C_i = (D_i, M_i, f, c, g)$ is called a *sub-contest*. Note that the model does not constrain the prizes to be awarded in the sub-contests, which can be different for different sets of agents.

Equilibrium Analysis. A comprehensive equilibrium analysis of a single contest of the kind considered in this paper can be found in the work of Ghosh and Kleinberg (2016). Here the optimal strategy is proved to be based on a threshold such that A_i chooses to participate iff its quality is greater than some threshold r_i and otherwise does not participate.

4 THE BENEFIT IN CONTEST PARTITIONING

In this work we demonstrate that partitioning a contest is often advantageous, even if sub-contests of size 1 (singletons) are considered. When using a sub-contest of size 1, agent participation can be induced by offering a prize $M = c$ (which, from the organizer's point of view, dominates any other prize $M' > c$). This is equivalent to hiring the agent, offering it exactly (or marginally higher than) its participation cost. The use of such singletons provides the organizer a better control over which of the agents will participate, as the actions of the singleton agents are driven by the direct payments they receive rather than competition dynamics. Yet, when doing so, the organizer loses the main advantage of the contest mechanism as a means for eliciting agents' private information. In our case, it is the competition dynamics that keep those agents with low contribution qualities (which the organizer cannot identify a priori) from participating in the contest, hence the prize offered becomes more effective in eliciting the participation of agents associated with high contribution qualities.

Figure 1 depicts the organizer's expected profit (using the optimal prizes) as a function of her partitioning cost c_p (which applies also when one of the sub-contests is a singleton), and when maximizing the sum of agents' qualities. The setting includes four agents ($k = 4$), participation cost $c = 0.1$ and uniform quality distribution between 0 and 1. The curves presented correspond to the following partitions: (a) $\mathcal{A}_1$, where the grand contest of all four agents is used; (b) $\mathcal{A}_2$, where two 2-agents sub-contests are used; (c) $\mathcal{A}_3$, where one sub-contest of one agent and one sub-contest of three agents are used; (d) $\mathcal{A}_4$, where two sub-contests of one agent and one sub-contest of two agents are used; and (e) $\mathcal{A}_5$, where four single agent contests are used. From the figure we observe that for $0 \leq c_p \leq 0.16$ the optimal partition is to 4 sub-contests of size 1.

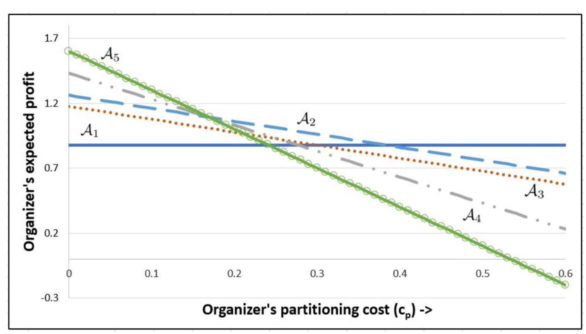

Figure 1: The organizer's expected profit as a function of her partitioning cost when using the *sum* aggregation function. See main text for the setting used.

REFERENCES

[1] Ghazala Azmat and Marc Möller. 2009. Competition among contests. *The RAND Journal of Economics* 40, 4 (2009), 743–768.

[2] Mürüvvet Büyükboyaci. 2016. A Designer'S Choice between Single-Prize and Parallel Tournaments. *Economic Inquiry* 54, 4 (2016), 1774–1789.

[3] Subhasish M Chowdhury and Sang-Hyun Kim. 2017. "Small, yet Beautiful": Reconsidering the optimal design of multi-winner contests. *Games and Economic Behavior* 104 (2017), 486–493.

[4] Pradeep Dubey. 2013. The role of information in contests. *Economics Letters* 120, 2 (2013), 160–163.

[5] Gil S Epstein, Shmuel Nitzan, and Mordechai E Schwarz. 2008. Performance and prize decomposition in contests. *Public Choice* 134, 3-4 (2008), 429–443.

[6] Qiang Fu and Jingfeng Lu. 2009. The beauty of "bigness": On optimal design of multi-winner contests. *Games and Economic Behavior* 66, 1 (2009), 146–161.

[7] Qiang Fu and Jingfeng Lu. 2012. The optimal multi-stage contest. *Economic Theory* 51, 2 (2012), 351–382.

[8] Xi Alice Gao, Yoram Bachrach, Peter Key, and Thore Graepel. 2012. Quality Expectation-variance Tradeoffs in Crowdsourcing Contests. In *Proceedings of the Twenty-Sixth AAAI Conference on Artificial Intelligence* (Toronto, Ontario, Canada). 38–44.

[9] Arpita Ghosh and Robert Kleinberg. 2016. Optimal Contest Design for Simple Agents. *ACM Transactions on Economic and Computation* 4, 4, Article 22 (2016), 22:1-22:41 pages.

[10] Oliver Gurtler, Johannes Munster, and Petra Nieken. 2013. Information Policy in Tournaments with Sabotage. *The Scandinavian Journal of Economics* 115, 3 (2013), 932–966.

[11] Michal Habani, Priel Levy, and David Sarne. 2019. Contest manipulation for improved performance. In *Proceedings of the 18th International Conference on Autonomous Agents and MultiAgent Systems (AAMAS)*. 2000–2002.

[12] Isa E Hafalir, Rustamdjan Hakimov, Dorothea Kübler, and Morimitsu Kurino. 2018. College admissions with entrance exams: Centralized versus decentralized. *Journal of Economic Theory* 176 (2018), 886–934.

[13] Coral Haggiag, Sigal Oren, and Ella Segev. 2022. Picking the Right Winner: Why Tie-Breaking in Crowdsourcing Contests Matters. In *IJCAI-International Joint Conferences on Artificial Intelligence Organization*. 307–313.

[14] Ming Hu and Lu Wang. 2021. Joint vs. separate crowdsourcing contests. *Management Science* 67, 5 (2021), 2711–2728.

[15] Daniel Krähmer. 2007. Equilibrium learning in simple contests. *Games and Economic Behavior* 59, 1 (2007), 105–131.

[16] Ersin Körpeoğlu, C. Gizem Korpeoglu, and Isa Emin Hafalir. 2018. Parallel Innovation Contests. (2018). Working Paper.

[17] Priel Levy. 2018. Optimal contest design for multi-agent systems. In *Proceedings of the 2018 AAAI/ACM Conference on AI, Ethics, and Society*. 376–377.

[18] Priel Levy, Yonatan Aumann, and David Sarne. 2024. Contest partitioning in binary contests. *Autonomous Agents and Multi-Agent Systems* 38, 1 (2024), 7.

[19] Priel Levy and David Sarne. 2018. Understanding Over Participation in Simple Contests. In *Proceedings of the AAAI Conference on Artificial Intelligence*. 1571–1578.

[20] Priel Levy, David Sarne, and Yonatan Aumann. 2018. Tractable (Simple) Contests. In *Proceedings of International Joint Conference on Artificial Intelligence (IJCAI)*. 361–367.

[21] Priel Levy, David Sarne, and Yonatan Aumann. 2019. Selective information disclosure in contests. In *Proceedings of the 18th International Conference on Autonomous Agents and MultiAgent Systems (AAMAS)*. 2093–2095.

[22] Priel Levy, David Sarne, and Yonatan Aumann. 2019. Temporal Information Design in Contests. In *Proceedings of International Joint Conference on Artificial Intelligence (IJCAI)*. 428–434.

[23] Priel Levy, David Sarne, and Yonatan Aumann. 2023. Tractable Binary Contests. *ACM Transactions on Economics and Computation* (2023).

[24] Priel Levy, David Sarne, and Michal Habani. 2020. Simple Contest Enhancers. In *2020 IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT)*. IEEE, 463–469.

[25] Priel Levy, David Sarne, and Igor Rochlin. 2017. Contest Design with Uncertain Performance and Costly Participation. In *Proceedings of International Joint Conference on Artificial Intelligence (IJCAI)*. 302–309.

[26] David Sarne and Michael Lepioshkin. 2017. Effective Prize Structure for Simple Crowdsourcing Contests with Participation Costs. In *Proceedings of the Fifth AAAI Conference on Human Computation and Crowdsourcing (HCOMP)*. 167–176.

[27] Pamela Schmitt, Robert Shupp, Kurtis Swope, and John Cadigan. 2004. Multi-period rent-seeking contests with carryover: Theory and experimental evidence. *Economics of Governance* 5, 3 (2004), 187–211.

[28] Roman M. Sheremeta. 2010. Experimental comparison of multi-stage and one-stage contests. *Games and Economic Behavior* 68, 2 (2010), 731 – 747.

[29] Noam Simon, Priel Levy, and David Sarne. 2022. Obtaining and Providing Partial Information in Binary Contests. In *2022 IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT)*. IEEE, 191–198.

[30] Noam Simon, Priel Levy, and David Sarne. 2024. Costly information providing in binary contests. *Annals of Mathematics and Artificial Intelligence* 92, 5 (2024), 1353–1375.