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FEATURE ARTICLE

The Opportunists in Innovation Contests

Understanding Whom to Attract and How to Attract Them

The opportunist-transactor dichotomy, which bridges whom to attract and how to attract them, is an important new consideration for all organizations—public and private— that use innovation contests. Characterizing solvers according to this new dichotomy is a better predictor of success.

Ademir Vrolijk and Zoe Szajnfarber

OVERVIEW: Organizations increasingly turn to innovation contests for solutions to their complex problems. But these contests still face a fundamental inefficiency: they need to attract many participants to find the right solution, resulting in high costs and uncertainty. Studies have identified multiple dichotomies of successful and unsuccessful solver types, but these diverge. These studies also offer little guidance on how to attract successful solver types. We introduce the opportunist-transactor dichotomy, bridging whom to attract and how to attract them. Opportunists view the contest as a onramp to a new pursuit instead of a temporary undertaking. Characterizing solvers according to this new dichotomy was a better predictor of success than existing ones: in our context, most winners were opportunists. This type of solver was also reliably attracted by the seeker's in-kind incentives, unlike those described by the other dichotomies. Our insights provide a deeper understanding of participants in complex contests and a concrete lever for influencing who shows up to solve.

KEYWORDS: Innovation contest, Crowdsourcing, Open innovation, NASA, In-kind incentives

Technical organizations are increasingly looking to crowdsourcing—and innovation contests specifically—for new solutions to their problems (Chesbrough 2017; Gustetic et al. 2015; Lakhani et al. 2013). These activities excel at reaching and gathering input from individuals and organizations outside of the domain of the problem (Afuah and Tucci 2012), which is a problem-solving approach that innovation scholars have long advocated for (Tushman 1977). In an innovation contest, an organization—the "seeker"—broadcasts its problem(s) to a broad audience for their input. In turn, participants—the "solvers"—compete for a prize by solving said problem(s) (Terwiesch and Xu 2008). Both the academic literature and the popular press have reported crowdsourcing's numerous successes in solving problems (Howe 2006; Piller and Walcher 2006), even complex ones (Lyden 2007; Vrolijk, Roman, and Szajnfarber 2022).

But innovation contests face an inherent tension. Though they excel at attracting many participants from various domains, the abundance of their solutions does not guarantee the seeker will find one that works. Scholars note that these failures are often caused by too many (poorly performing) solvers (Alexy, Criscuolo, and Salter 2012; di Gangi, Wasko, and Hooker 2010). The seeker gets bogged down in evaluating their solutions, favoring familiar ones and missing potential breakthroughs (Dahlander and Piezunka 2014, 2020). Thus, attracting many solvers is not always a good strategy to solve the seeker's problem. Sometimes, the seeker needs a narrower approach.

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One such narrowed approach requires seekers to address questions like *whom to attract* and *how to attract them* at the same time. Jeppesen and Lakhani's study (2010) was the first to show that certain solver types were more likely to outperform others. In their study, solvers who were (somewhat) removed from the domain of the problem were more likely to win the contest (Acar and van den Ende 2016; Poetz and Prügl 2010). Since then, scholars have identified several solver characteristics correlated to performance—like their familiarity with the problem (Afuah and Tucci 2012; Szajnfarber et al. 2020) or their motivations for participating (Acar 2019; Seidel and Langner 2015). These studies propose dichotomies of successful and unsuccessful solvers, but each dichotomy differs in how it categorizes them. Thus, they paint a jumbled picture of what kind of solver is more likely to successfully solve the seeker's problem. Additionally, none of these studies connect their findings to the incentives needed to attract the archetype(s) in question.

In this paper, we connect the performance of different solver archetypes to the incentives that can attract them. Our data comprised 60 solver teams from seven complex crowdsourcing contests at the National Aeronautics and Space Administration (NASA). We coded these teams according to two dichotomies of solver types found in the literature and one other we introduce in this paper, *opportunists vs. transactors*. Opportunists intended to use the contest as an onramp to new opportunities—building a revenue stream, developing and demonstrating their technology, or establishing themselves in an industry. This dichotomy predicted most winners across the contests we studied, outperforming the existing dichotomies. And unlike the other successful solver types, opportunists were consistently incentivized by the seeker's in-kind prizes and support. These results enhance our understanding of innovation contests and support seekers in addressing their short- and long-term organizational goals.

Literature Review

We review the inefficiencies faced by innovation contests and three dichotomies of successful and unsuccessful solver types. We then describe how these dichotomies lack a connection to ongoing work on contest incentives, addressing some of the inefficiencies we mentioned.

Making Innovation Contests More Efficient

Seekers design innovation contests to reach many potential solvers. The number and breadth of solvers, and related submissions, can be detrimental to its outcomes, however. Reviewing and selecting solutions is a daunting task for the seeker, be they thousands of suggestions (Alexy, Criscuolo, and Salter 2012; Bjelland and Wood 2008) or hundreds of complex solutions (Szajnfarber et al. 2020). This issue is amplified when the seeker needs to translate the solvers' solution knowledge into their domain (Piezunka and Dahlander 2015; Ruiz, Brion, and Parmentier 2020). The seeker is simply "overwhelmed," and good but unfamiliar ideas may fall through the cracks (Blohm, Leimeister, and Krcmar 2013, p. 200). Thus, the participation of many solvers may negate the contest's ability to find a solution that solves the seeker's problem.

Scholars have proposed two approaches to address this tension, making contests more efficient in finding solutions. The first focuses on identifying good solutions that will address the seeker's need, even if they might seem unfamiliar at first. Strategies related to this approach spread the burden of reviewing the solutions: allowing others to characterize (Westerski, Dalamagas, and Iglesias 2013), rate (Hoornaert et al. 2017; Jensen, Hienerth, and Lettl 2014), or provide feedback on the solutions (Huang, Vir Singh, and Srinivasan 2014; Seidel and Langner 2015). Alternatively, the seeker may also limit the number of submissions to make the review process easier (Piezunka and Dahlander 2015). The second approach focuses on identifying good solvers, those who are likely to perform well in a contest. Here, scholars have characterized traits that correlate with the solver's likelihood of submitting high-performing solutions (Acar and van den Ende 2016; Franke, Poetz, and Schreier 2013; Jeppesen and Lakhani 2010; Szajnfarber et al. 2020).

The two approaches also differ regarding *when* in the contest process they get implemented. Most of the work related to a solution-focused approach occurs downstream: reviewing the solutions can only happen once solvers submit them. On the contrary, the work to implement a solver-focused approach occurs upstream, when the seeker formulates their contest. In this approach, seekers focus the search as they decide on the specifics of the contest's problem, its structure, and its administration (Kiran and Sharma 2021; Paik et al. 2020; Vrolijk, Roman, and Szajnfarber 2022). Here, deciding what solvers to target and how to do so is crucial. This effort needs to be coordinated and implemented across the different aspects of the contest, like marketing, problem description, and, importantly for this work, the size and make-up of the prize award.

To date, the solver-focused approach lacks practical guidance. Several studies have examined how a seeker can implement the solution-focused approach. Yet, few studies have done the same for the solver-focused one. Specifically, we lack guidance on how the seeker can target (likely) good solvers. Our work addresses this gap by linking who the best solvers are to an actionable lever at the seeker's disposal.

Who Should Contests Attract?

We present three perspectives that characterize who the best solvers are—two articulated in the literature and one we introduce in this paper. Each perspective uses a dichotomy to explain why a solver does well: those who have a particular characteristic are likely to do better than those who do not. The characteristics span the solvers' home domain or industry (distance is better); familiarity with the technical problem or topic (familiarity is better); or planned technological trajectory (same intent is better). We describe each dichotomy through the solver archetype that it advocates: distant solver (vs. local solver), solution neighbor (vs. stranger), and opportunist (vs. transactor), respectively.

Distant Solvers—Good solvers do not always stem from different domains—or industries—as the problem they are solving (Acar and van den Ende 2016; Jeppesen and Lakhani 2010; Poetz and Schreier 2012; Schuhmacher and Kuester 2012; Zhu, Li, and Andrews 2017). Rather, they stem from its margins or come from other domains entirely (Franke, Poetz, and Schreier 2013). For example, the study of solar storms falls under NASA's heliophysics umbrella. However, a radio engineer won a contest to predict potentially destructive events (Lifshitz-Assaf 2018). He drew on his domain's expertise for his solution, far surpassing NASA's in-house algorithms. Generally, these solvers succeed because, unlike the focal domain's experts, they are less likely to be burdened by cognitive entrenchment or fixation on a dominant design (Dane 2010; Jansson and Smith 1991).

Solution Neighbors—Afuah and Tucci (2012, p. 360) described good solvers as being "close to the highest peak" on the solution landscape, so "they do not have to go outside their immediate knowledge neighborhood." Their problem-solving strength rests on their proximity to a good—or the best—solution; little searching is needed to deliver this solution to the seeker (Frey, Lüthje, and Haag 2011; Lakhani et al. 2007; Magnusson 2009). Simply put, these solvers are experts and can be identified as such. The contest merely connects them to the seeker and allows them to display this expertise (Szajnfarber and Vrolijk 2018; Szajnfarber et al. 2020). For example, the Ansari XPRIZE challenged solvers to design and demonstrate a reusable, crewed vehicle capable of parabolic spaceflight (Kay 2011). Here, the winning team was an aircraft design company. The XPRIZE Foundation awarded the $10 million prize purse to Scaled Composites in 2004. While this contest was its first foray into space, the company had a long track record of designing and flying experimental vehicles that outperformed existing models.

Opportunists—We contend that good solvers, sometimes, see the problem—and their solution—as a worthy, long-term pursuit. These solvers pursue opportunities in the seeker's domain after the contest ends, regardless of the industry they were in before the contest. Thus, opportunists are solvers with an (intended) technology trajectory that is aligned with the contest. This pivot mirrors the trajectory of some user-innovators (von Hippel 2005): realizing that they might fill a gap in the market, users sometimes commercialize a solution initially designed to address their own needs despite being an outsider to that industry (Shah and Tripsas 2007, 2016).

Some opportunists even end up working for the seeker. For example, the Northrop-Grumman Lunar Lander Challenge winner and runner-up were rocket companies aiming for commercial success. Masten Space Systems and Armadillo Aerospace won $1 million and $500,000, respectively, in the 2009 contest. In fact, the former "was organized as a small rocketry and propulsion start-up that focused its activities on pursuing the prize challenge" (Kay 2011, p. 372). After successfully demonstrating their hardware in the contest, NASA awarded both companies contracts to further their rocket technologies (Gustetic et al. 2015).

To them and other solvers in their position, the contest is a "springboard" that helps them accomplish their (existing) goals. Their problem-solving strength may lie in their ability to foresee gaps in current solutions or approaches that others do not (Lüthje and Herstatt 2004; von Hippel 1986). With their intended long-term presence, the opportunists' strength may also lie in their ability to marshal knowledge and financial resources to solve the problem (Kay 2012).

While knowing whom to attract might be the first question to tackle, equally important is knowing how to attract those solvers.

How to Attract Desired Solvers?

While knowing *whom to attract* might be the first question to tackle, equally important is knowing *how to attract* those solvers. To date, several studies explored why solvers participate in innovation contests. One perspective among these studies draws on the psychology literature to trace the solvers' motivations (Deci and Ryan 2000; Ryan and Deci 2000). It focuses on why solvers would decide to participate in these contests. Studies describe intrinsic (for example, having fun or learning new skills) or extrinsic (for example, winning a prize or recognition from others) motivations as strong determinants for participation and for quality of solutions (Acar 2019; Frey, Lüthje, and Haag 2011; Lakhani, Garvin, and Lonstein 2010; Lakhani et al. 2007; Mack and Landau 2015). However, these studies often lack actionable guidance to practitioners concerning solvers' motivations: what incentives—and at what levels—should the seeker set to connect to those motivations?

Another perspective takes a different view: focusing on the lever(s) that the seeker can use to draw participants to the contest. It draws on the literature on tournaments to motivate the desired effort in a contest environment (Fullerton et al. 1999; Shavell and van Ypersele 2001; Taylor 1995). Specifically, these studies address how (different) prize *incentives* affect solvers' participation—a feature of the contest that the seeker can easily and actively shape. They specify the (levels of) monetary and (kinds of) non-monetary incentives (for example, medals, IP rights, or media attention) that the seeker can use (Davis and Davis 2004; Ihl, Vossen, and Piller 2019; Kay 2011; Leimeister et al. 2009; Murray et al. 2012). Some even specify how certain kinds of incentives might be more successful in inducing innovative behavior than others (Brunt, Lerner, and Nicholas 2012). However, these studies provide little insight into *who* responds to those incentives or how to attract winners.

Bridging the "Who" and the "How"

While organizations can accrue a wide range of benefits by using innovation contests to solve their problems (Vrolijk, Roman, and Szajnfarber 2022), solutions are still the driving reason for doing so. In the eyes of the seeker, increasing the likelihood of finding successful solutions makes these contests more appealing. A lot of work has been done to identify likely winners in the crowd. However, much less has been done to understand how to attract them. Thus, there is a gap between who seekers should be targeting and how they should set their prize(s) to incentivize their participation. We bridge this gap below.

Setting, Data, and Methods

Our understanding of innovation contests generally, and of the solvers within them specifically, is still at an early stage (Bogers et al. 2017; Eisenhardt, Graebner, and Sonenshein 2016). The literature recommends qualitative data and analysis methods to identify and capture the relevant dynamics (Edmondson and Mcmanus 2007; Szajnfarber and Gralla 2017). Following this guidance, we selected a setting where we could collect the relevant data and analyze them accordingly.

This setting is NASA's Centennial Challenges Program (CCP), the agency's flagship for challenging complex, crowdsourcing contests. Informed by the agency's technology roadmaps, each CCP contest aims to advance technologies crucial to achieving NASA's near-term goals. To that end, NASA subject matter experts (SMEs) formulate these contests to complement their ongoing efforts, and create scoring rubrics that rank submissions on their performance and feasibility (Vrolijk and Szajnfarber 2021).

We observed seven active contests within this portfolio (Table 1), with prize purses ranging from $50,000 to $5.5 million. Each contest had its own technical focus, solvers, and relevant SMEs. They were usually divided into smaller sub-contests with their own submissions, scoring rubrics, and prize award. Participating solo or as a team, solvers came from academic, industry, and hobbyist backgrounds—affiliations categorized by the contests' staff. The seven contests counted a total of 227 solver teams, of which 28 were winners—they received the top prize in at least one of their contest's awards. In short, the nature of the contests in the CCP portfolio and the variation of solvers in each contest provided us with an ideal setting to explore our research question.

The data for our study consisted of semi-structured interviews with 60 solver teams across the 7 contests (Converse and Presser 1986). This sample also contained teams from academic, industry, and hobbyist backgrounds—26, 18, and 16 teams, respectively. Considering the solver team as our unit of analysis, we interviewed each team's chosen representative(s) about their participation. Our questions covered their demographics and experiences, reasons for entering the contest, their solution's basis and relevance to their work outside the contest, and any future plans. These broad questions allowed the representatives to freely explain who the team was. It also allowed them to elaborate on their relationship with the contest and its subject matter. Of the 60 teams in our data, 22 were winners. In total, we gathered 37 hours of interviews and transcribed these for further analysis.

Coding Participants per the Dichotomies

With our interview data transcribed, we deductively coded the teams according to the three dichotomies (Miles and Huberman 1994). Importantly, we were not interested in the correspondence among the dichotomies but rather their ability to predict winners. We characterized each team as a distant solver (or not), a solution neighbor (or not), and an opportunist (or not). We note here that culture (Chua, Roth, and Lemoine 2015), gender (Jeppesen and Lakhani 2010), or intrinsic motivations (Acar 2019) may also predict contest success. We chose not to include these characterists, however, as it is difficult to accurately measure them across both individuals and teams. We discussed and resolved any disagreements that emerged during coding. We explain our process and provide examples.

Distant Solver vs. Local Solver—To identify distant solvers in our sample, we examined teams' home industry before the

TABLE 1. Overview of contests we studied

Contest	Prize ($k)[a]	Teams[b]	Winners[c]	Technical Focus
Mars Ascent Vehicle[d]	50	15	1	Automated loading and launching of Mars samples
Vascular Tissue	500	7	1	Growing and sustaining human tissue
Space Robotics[e]	1,000	92	1	Simulating robot operations on Mars
CO_2-to-Glucose	1,000	24	6	Converting CO_2 into bio-feedstocks
Sample Return Robot[f]	1,500	16	6	Automated locating and collecting of Mars samples
3D Printed Habitat	2,450	60	6	Additive construction of habitats on Mars
CubeQuest	5,500	13	7	Deploying miniature satellites in deep space

[a]Total prize pot available per contest;
[b]Number of teams participating per contest (227 in total);
[c]Number of teams that received at least one top prize across all prize awards per contest (28 in total);
[d]The 2016 contest;
[e]Phase 1;
[f]The 2016 contest.

contest. Taking the seeker's perspective, we coded teams with substantive ties to the space industry as "local." In these cases, team members described previous experiences in the space industry or how their team (or its parent organization) was engaged in space-related activities. Otherwise, we coded the team as "distant." Here, solvers also described their differences or unfamiliarity with NASA or the space industry.

We present a quotation from one such distant solver in the 3D Printed Habitat (3DPH) Challenge. The team—a pre-revenue startup at the time—operated in the construction industry before entering the contest. As the representative explains, their company's focus was creating 3D printing tools that made construction projects more efficient. "We've been going for a little over three years, mostly going after the construction market. Working with architects and designers. Because what [our technology] offers is. . .unprecedented design freedom and resource stewardship in the resource arena," they said. "The way that we do that is through prefabricating architectural wall panels that are printed. That's the tool. The goal is not necessarily to be a 3D printing company, the goal is to enable change in the construction industry."

Solution Neighbor vs. Solution Stranger—We identified teams as solution "neighbors" if they described the team's familiarity with the problem posed or the technology being challenged in the contest. These solvers mentioned the related projects they worked on, past or current, and described how these experiences informed their participation. Importantly, teams described their familiarity with the problem or technology independent of their industry. In contrast, we coded solvers as a solution "stranger" if they indicated that the subject matter was new to them or if they did not comment on their familiarity with the problem.

For example, one solution neighbor in the 3DPH Challenge described how their core technology overlapped with the contest's problem. 3D printing buildings was not a new pursuit when they entered NASA's contest, and they based their solutions on this existing work. To them, this overlap was evident despite being rooted in the (terrestrial) construction industry. They said, "Before starting the challenge, we were interested in developing this technology for building houses on Earth. . . .We were already concerned with the 3D printing of buildings, finding ways to doing 3D printing of buildings using forms of concrete. Basically it aligns with the goals of the competition."

Opportunist vs. Transactor—We coded teams as "opportunists" if they entered the contest to explore new technical opportunities. Their intended trajectory was the most important distinguishing characteristic. Opportunists would describe the contest as a springboard for this exploration, impacting their careers, technological, and organizational trajectories. Through their participation, they intended to build a revenue or income stream, further develop and demonstrate a technology they were interested in, or establish themselves within the industry they were targeting. One or more of these pursuits were crucial parts of their reason to participate. In contrast, we coded teams as "transactors" if they stated that their attention to the subject matter would be limited to this contest or did not mention any such plans.

An opportunist in the CubeQuest Challenge describes how they approached this contest: "We are, from the start, viewing this [contest] as a commercial activity. Basically, what we're trying to go off and do is, from the start, design something that makes economic sense to fly." From the start, their goal was to use their efforts in the contest to produce a commercially viable product, not just win the competition. This meant designing their CubeSat with this pursuit in mind, not just the contest's rules—the contest would serve as their entrepreneurial springboard.

Coding Incentives

We inductively coded the teams' transcripts to uncover the incentives that motivated them to participate (Strauss and Corbin 1990). Recall that despite the abundance of prior work, a connection between the kinds of solvers who win contests and the incentives that attract them is missing. Thus, we explored it within our context. We first identified text fragments that described what attracted them to the contest(s). Then, we organized these fragments into common, higher-order categories. We iterated through these data and adjusted the categories until we reached a stable set of eight categories. Some incentives were more closely tied to the space industry than others—that is, networking in the space domain, recognition by space SMEs, and accessing the seeker's infrastructure and services. We then coded each team for the relevant incentive categories. We present the categories, and example quotations by teams' representatives (Table 2).

Results

Our findings connected the most successful type of solver to the incentives that consistently attract them. Here, the opportunist-transactor dichotomy was most able to predict winners: most winners in our context were opportunists. Additionally, the seeker's in-kind incentives consistently attracted this solver type, and not others, to participate.

Opportunists Outperformed Other Successful Solver Types

We summarize the types of teams and winners in our sample (Table 3). Most of these winners—15 out of 22—were opportunists, the successful solver type in its dichotomy. We then compared this result to the other dichotomies: how well each one identified the solvers who won a top prize. Neither the distant-local solver nor neighbor-stranger dichotomies identified as many winners: they counted 12 and 8, respectively. As such, the opportunist-transactor dichotomy predicted winners in our sample better than the others.

We also contend that this finding generalizes to all 28 winners in our context. First, we saw no apparent differences between winners in our sample and those missing from it. When comparing the distribution of affiliations, winners we interviewed came from academic (36 percent), industry (46

TABLE 2. Incentives categories coded in our data

Incentive Category[a]	Teams in Sample[b]	Key Terms	Example Quotation
Networking in space domain	5	Contacts with NASA, stakeholders	"We [participated] mainly because we were interested in getting some contacts with NASA."
Recognition from space SMEs	8	Demonstrate, showcase	"We really have robust material engineering innovation, which I think is much more relevant to NASA at a practical level. I think that our recipe could be something that they can take on the Moon, on Mars, whatever. I think it's probably something they don't know, haven't thought about, and [yet] is extremely relevant."
Seeker's infrastructure and services	4	Access, do for us	"What, in effect, the [challenges] are doing for us is they're providing another example of a tough room. People that are willing to go through and review our designs."
Challenge structure	6	Deadlines, goals	"We're doing the competition because it aligns . . . The competition helps us because it has rigid deadlines. It helps us to pull everything together to meet the deadlines. It helps to move the research a bit faster."
Money	16	Prize money, dollars	"Then I said [to my teammate], 'The top prize is like 1.5 million dollars.' This is on Skype and he's typing, and there's a pause and then he says, 'Oh really?' And then after that it was like, 'Yeah, we should do this."'
Networking in non-space domain	3	Interaction, network	"So as I said, the challenge, I'm not really looking at it as an end product, more like an avenue for interaction, going to these conferences, see the latest trend. I look at these challenges like more of a network rather than funding."
Publicity	6	Publicity, branding	"We thought we could get some publicity."
Recognition from non-space SMEs	7	Seen as experts, prestige	"We hope to publish our results [in a non-space journal] in some form."

[a]The first three incentives tie closely to the space industry; the next five do not.
[b]The number of teams in our sample that mentioned this incentive category.

percent), and hobbyist (18 percent) backgrounds in similar proportions to those we did not: 33, 50, and 17 percent, respectively. Second, most missing winners were likely to be opportunists. Winners from both academia and industry—the majority of teams—were more likely to be opportunists rather than transactors: 88 and 70 percent, respectively. Additionally, the likelihood of these winners being opportunists (vs. transactors) equaled or dominated the likelihoods of being one of the other successful types. Combined, we expected most winners—in our sample or not—to be opportunists rather than distant solvers or solution neighbors.

In-kind Incentives Attracted Opportunists

We analyzed how different incentives motivated the different solver archetypes. We matched the incentives categories revealed by our coding with the archetypes, per dichotomy, that describe them as motivators for their participation (Table 4). Each entry in the table describes which type(s) mentioned a particular incentive. For example, when comparing solution neighbors and strangers, only the latter described networking in a non-space domain as an incentive to participate. In contrast, cells with a "both" entry indicate that both types within that dichotomy mentioned that incentive.

Once again, the opportunist archetype stood out among the others. In our data, the incentives hardly differed between the distant vs. local solver and neighbor vs. stranger dichotomies: the incentives equally attracted successful and unsuccessful types (with two exceptions). This was not the case for opportunists. They consistently mentioned four incentives that transactors did not. Most of these were in-kind incentives within the space industry—the same domain as the seeker.

The first incentive was networking with NASA SMEs who work in the problem's topic area. The opportunists described how they participated "mainly because we were interested in getting some contacts with NASA." The contest was a reliable way to meet key people in an industry they were interested in "without cold calls."

The second was recognition by NASA SMEs for their technical achievements. Assuming that they would create a strong submission, the opportunists believed the contest could help them "[get] our name out there with the community [and be] a part of that whole group." They could

Winners from both academia and industry—the majority of teams—were more likely to be opportunists rather than transactors.

TABLE 3. **Three solver dichotomies and their performance across NASA's Centennial Challenges**

Dichotomy	Teams in Sample[a]	Winners in Sample[b]	Example Quotation of Winning Solver Archetypes[c]
Distant (vs. Local)	30 (30)	12 (10)	"So, we always wanted to get into aerospace, slash [International] Space Station use, slash Mars use. NASA's CO_2 Conversion Challenge—the timing was just really good because they released the CO_2 Conversion Challenge when we already knew we wanted to get into aerospace." "My background [is] molecular biology and biotech. And my master's work, I did a research master's for it in medical biophysics. And mostly health-based molecular research. So that's where I'm coming from, which is not here." "As an architect, I participated in many different architectural competitions. This is a very different one: out of the box and out of the world with a very good cause."
Solution Neighbor (vs. Stranger)	22 (38)	8 (14)	"Before starting the challenge, we were interested in developing this technology for building houses on Earth. We were already concerned with the 3D printing of buildings, finding ways to doing 3D printing of buildings using forms of concrete. Basically, it aligns with the goals of the competition." "A common friend of ours had shown up to the third competition and seen what was going on and figured out that we had a pretty decent shot at winning a million dollars. And he had a robot in his closet that we could use as a platform that they had worked on during their senior project here." "And then we saw this NASA contest about 3D-printed habitats for Mars, and we thought that this is right up our alley. Exactly what we're exploring as well."
Opportunist (vs. Transactor)	32 (28)	15 (7)	"We are, from the start, viewing this [contest] as a commercial activity. Basically, what we're trying to go off and do is, from the start, design something that makes economic sense to fly." "We hadn't done anything so far. But the whole point [of participating] was to make a CubeSat—the schematics for a CubeSat that would be [our university's] designed standard that would even further make it easier and cheaper to make CubeSat for universities and companies." "Initially, we were undertaking some research that had to do with electrolysis propulsion. When this prize opportunity opened up, we realized that that would be a way to demonstrate the technology that we had already been working on. For us, it helps achieve research goals."

[a]The dichotomies classified the 60 teams in our sample.
[b]The dichotomies classified the 22 winners in our sample.
[c]Quotations by Distant Solvers, Solution Neighbors, and Opportunists, respectively.

TABLE 4. **Incentives across different solver dichotomies**

Incentive Category[a]	Solver Dichotomy		
	Distant or Local Solver?	Solution Neighbor or Stranger?	Opportunist or Transactor?
Networking in space domain	Both	Both	Opportunist
Recognition from space SMEs	Both	Both	Opportunist
Seeker's infrastructure and services	Local	Both	Opportunist
Challenge structure	Both	Both	Opportunist
Money	Both	Both	Both
Networking in non-space domain	Both	Stranger	Both
Publicity	Both	Both	Both
Recognition from non-space SMEs	Both	Both	Both

[a]The first three incentive categories tie closely to the space industry, the next five do not.

then leverage that recognition within the industry, continuing the efforts started in the contest or pursuing related contracts.

The third was accessing NASA's infrastructure or services. As a large technical organization, NASA possesses a range of world-class infrastructure and expertise that surpass those possessed by individual solvers. The costs of accessing these commercially could range in the millions of dollars if they are available outside of NASA. Nevertheless, the contest provided access to NASA's infrastructure and expertise, something opportunists strongly desired. For example, one team—a CubeSat startup company—described how a "tough room" of NASA SMEs provided valuable, expert feedback on their designs that were intended for commercial markets after the contest. And while the contest's "[prize] money is somewhat motivating," another team described how a chance to fly to the Moon on NASA's new rocket was "the number one motivator" for them. They explained that the opportunity was unique and worth much more than the dollar value of the prize money. "[T]he opportunity to launch our spacecraft to lunar orbit itself has far more value than the dollar amount we would expect to bring in via the prize…. I don't think it's possible to buy a launch on [NASA's Space Launch System rocket], and if you could, I don't think it would be $200k, it would be way more than that."

The fourth was the contest's structure and timetable. The opportunists described how the contest—helpfully—imposed a structure on their development efforts. They sought this out because it drove them to organize their work to meet its deadlines. It also sped up in-process work: as one team put it, it helped them "to move the research a bit faster." Far from being an external burden, the contest's rigid structure and timetable actually helped these solvers achieve their goals.

Discussion

Organizations are increasingly launching innovation contests to help solve their problems (McCausland 2020). However, the cost of failure is high when one considers the high costs of organizing these contests, the importance of the problem, and the large sums of money on the line. To best use this tool, we need to reduce the inherent uncertainty in these contests (Bogers et al. 2017). In this vein, we explored a link between the contest's incentives and the types of solvers they can attract. Our findings contribute a better understanding of the solvers and their relationship to innovation contests, and practical insights that seekers can implement.

First, we introduced a new solver dichotomy: opportunists vs. transactors. The opportunist type views the contest as a springboard to new, related opportunities. The alignment between their long-term pursuits and the contest means participation is pivotal to their future rather than transactional. The opportunist-transactor dichotomy showed how solvers' (intended) trajectories "after and beyond crowdsourcing" (West and Bogers 2017, p. 45) impact their decisions to participate. This dichotomy predicted more winners than the others; most winners in our context were opportunists, not distant solvers or solution neighbors.

Second, we showed that the opportunist type responds to specific incentives. Contrasting with existing literature, our findings show that different types of solvers are not equally attracted to the same incentives. Instead, certain incentives can selectively target certain solvers. In the opportunist-transactor dichotomy, opportunists were consistently attracted to the in-kind incentives offered by the seeker. Their long-term trajectories made these kinds of incentives hugely valuable to their pursuits. By clarifying this relationship, we linked types of solvers—specifically those with a higher likelihood of winning—to the incentives that can attract them. With this insight, seekers can better influence who will show up to solve the contest problem.

Third, we showed that not all solvers are interested in short-term or low-intensity engagement with the contest's topic. In our context, solvers created significant, lasting organizational structures, and they pivoted to the contest's topic for the long term. Much like problem-solving or knowledge-producing entities more broadly, the solvers aimed to "efficiently generate knowledge and capability" (Nickerson and Zenger 2004, p. 617) and to consolidate the assets and resources needed to do so successfully (Kogut and Zander 1993; Nonaka 1994). Teams gathered the right expertise and raised enough funds to address the contest problem. This usually meant expanding their team and formalizing their organizational structure—much like a traditional firm would do. For example, one participant in the 3DPH Challenge described how they got involved with their team: "I probably wouldn't be involved at all [in additive construction] without this competition. They hired me. My background is in 3D printing entirely, and they hired me specifically for this."

The view of the contest as a springboard means that we need to adjust our perceptions of who participates. Opportunists used their efforts in the contest as a catalyst for long-term change—whether accelerating their current pursuits or opening new ones. This limits how much we can define the innovation contest as purely a temporary pursuit (Beretta 2019; Paik et al. 2020; Pollok, Lüttgens, and Piller 2019) or its solvers as "gig workers" (Shergadwala et al. 2020; Szajnfarber et al. 2020). At minimum, these labels do not apply to opportunists: they are not completing short-lived, similar tasks for a chance at a (monetary) prize. Rather, their long-term trajectories matter for their participation and the outcomes of the contest.

Finally, these findings also call attention to the structure of the contest's prize. Money has long been *the* incentive for innovation contests. Here, the tournament literature has searched for the appropriate, absolute cash value that incentivizes the desired behavior from solvers (Ehrenberg and Bognanno 1990; Fullerton et al. 1999). Instead, we show the value of in-kind prizes to do the same. These prizes can carry a high value for certain solvers, sometimes even more desirable than cash, but are comparatively cheap for the organization to offer. For example, publicly holding the solver in high esteem or providing access to in-house expertise and equipment might be easier and cheaper than an equivalent cash prize. As such, the seeker should consider a prize

The seeker should consider a prize portfolio instead of a prize pot: a mix of monetary and in-kind incentives that balances the seeker's costs, organizational goals, and the desired solver mix and turn-out.

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Certain aspects of this work might limit how broadly our insights apply. First, NASA's history with innovation contest winners might attract more opportunists to their contests. At least two previous high-profile Centennial Challenge winners have partnered with, or received major grants from, NASA to pursue technologies they produced during their contests. NASA SMEs see these contests as a possible source for new partners. Likewise, solvers with similar intent might be inspired to participate in contests hosted by the agency. As such, opportunists may be overrepresented in our context. This possibility does not detract from the importance of the dichotomy, however. On the contrary, non-NASA seekers would do well to create opportunities where contest winners could partner with them after their contest is over. With this onramp to the target domain, we would expect the same mix of dichotomies, and winners, in other contexts as in our study.

Second, our study only included innovation contests with prize pots above $50,000. Generally, these contests are considered complex: requiring more effort, focusing more investment, and attracting large and experienced teams who are motivated differently (Kay 2011; Murray et al. 2012). Yet, complex contests represent a small fraction of all contests launched, even at NASA (Gustetic et al. 2015). As such, the power of the opportunist-transactor dichotomy might not extend to most innovation contests—the other dichotomies might better predict the winners of simpler contests. We call on others to extend this work and determine the limits of each dichotomy.

Conclusion

The popularity of innovation contests as a problem-solving tool is increasing, even for complex problems. Understanding how we can shape contests to better serve the seeker's goals will allow them to put this tool to good use. Our study describes one lever to accomplish this shaping. Its findings link the contest's incentives to the kinds of solver who is more likely to win and provide useful knowledge to the seeker. To do so, we introduced a new solver dichotomy: *opportunists vs. transactors*. Here, opportunists see the contest as a springboard to future technical opportunities. Categorizing solvers this way was meaningful for two reasons. First, this dichotomy predicted winners in our context better than existing solver dichotomies—specifically, distant vs. local solvers and solution neighbors vs. strangers. Second, the incentives that attracted opportunists differed meaningfully from those that attracted other types. Specifically, NASA's space-related, in-kind support and prizes consistently incentivized opportunists and not transactors. This difference in incentives was not the case for the successful vs. unsuccessful solver types described by other dichotomies. Our results enhance our understanding of innovation contests and support practitioners looking to shape their next contest.

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