The Effects of Prize Structures on Innovative Performance[1]

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Online Appendix

A.1 Data Appendix

A.1.1 Research Setting and Experimental Design

A.1.1.1 Innovation Contest

In order to test how prize structure impacts the quantity and quality of innovation, we ran a randomized control trial (RCT) within an innovation contest that we hosted in partnership with Thermo Fisher Scientific, a large biotechnology company with a market cap in excess of 100 billion USD. The innovation contest was hosted by their Mexico office in Baja California and was open to all non-management employees of the firm as well as employees at other technology firms in the region.[2] To increase participation and help foster Thermo Fisher's recruitment interests, it was also promoted to STEM students at local universities.

The contest was advertised over a 45-day period through email blasts, posters, and announcements in industry newsletters. Promotion materials included information about the general topic area of the innovation challenge, the competition dates, and the total prize purse available to participants (15,000USD). The promotion materials also informed potential participants that the contest was being co-hosted by UC San Diego and Thermo Fisher, and that it was part of a research study on motivations for innovation.[3] Participation was open to individuals or teams of up to three people. In order to register for the contest,

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[1]This study is included in the AEA RCT Registry (AEARCTR-0004026). IRB approval for this study was obtained from the UC San Diego Human Research Protections Program (approval number 180938).

[2]Baja California is a Mexican state that borders California, USA. Thermo Fisher has an R&D office in the state and is working with local stakeholders to develop the region's STEM labor force.

[3]We were required to disclose that the contest was part of a research study by UC San Diego's Institutional Review Board. We opted to disclose during recruitment rather than after the competition was complete because ex post disclosure would require that participants are given the option to remove themselves from the study and we were concerned that this could lead to selective attrition based on competition outcomes.

participants were required to complete a brief survey and agree to the terms and regulations of the contest.[4]

At the start of the competition, the details of the innovation challenge were announced and participants were given 54 hours (from 6 pm on a Friday until midnight the following Sunday) to submit their entries. Submissions were made through DevPost, a popular commercial platform for hosting software innovation contests. Our contest design was informed by discussions with management at Thermo Fisher and other large companies that use innovation contests as part of their R&D strategy. This effort was undertaken to ensure that it is representative of the types of contests being used throughout industry. For instance, many Fortune 500 companies run short contests both for customers and employees and, as in our setting, these contests lay out a specific problem to be solved (Rathi, 2014). Moreover, many of these contests are run over a short period of time. For instance, the typical hackathons hosted by DevPost, the world's largest hackathon platform, last 1-3 days. These include contests hosted by CapitalOne, IBM, Y-Combinator and many other Fortune 500 companies. Importantly, companies report that these contests generate important innovations. For instance, a 24-hour contest hosted by an insurance company yielded a completely new model for processing healthcare claims (Grijpink et al., 2015). Moreover, our contest is significantly longer and more closely resembles the types of contests companies are hosting to generate new products and services than those studied by much of the existing literature. Crowdsourced innovation, like innovation contests, is forecasted to be worth up to 2 billion USD by 2024 (Markets & Markets, 2019).

Our contest challenge was focused on addressing local health technology needs, with the specifics determined through a consultative process between the study authors and research managers at Thermo Fisher to ensure commercial relevance to the industry. The contest problem was carefully chosen to ensure that reasonable progress could be made during the time allotted for the competition.

In particular, participants were provided with the following text at the opening of the competition window: *Mexico has many small health care providers and research and clinical*

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[4]The contest rules are included in Section A.1.2.

laboratories that, on their own, cannot afford expensive equipment that would allow them to provide the highest quality care possible. We believe that the proliferation of digital and cloud technologies can help to solve this problem. We are asking you to show us how you think these technologies can be used to support access to high-quality medical equipment even for these small health care providers and labs.

A.1.1.2 Experiment Implementation

To generate random variation in the prize structure, we randomly assigned participants to one of two prize menus both with a total of 15,000USD available to contest winners, corresponding to approximately 79% percent of 2018 annual incomes for software developers in Mexico (Statista, 2019). The first prize structure was a winner-takes-all design in which a single prize of 15,000USD would be given to the highest ranked submission. The second prize structure, provided awards to the ten highest ranked submissions. Submissions ranked first, second, third, and fourth received $6,000, $3,000, $1,500, and $900 respectively, and submissions ranked fifth to tenth received $600. Given an equal number of competitors in both study arms, the expected return for would be innovators is identical across the two arms, but the standard deviation of expected returns and corresponding participant risk of failure, is higher in the winner-takes-all arm.

Randomization was performed following the enrollment deadline and stratified by team and individual participants to ensure equal numbers of teams and individuals in both contest arms. As Tables A.1 and A.2, included in section A.2 below, demonstrate, assignment into contest arms is unrelated to participant demographics and characteristics.

Participants were given information about the prize structure they would face at the same time they were provided details on the innovation challenge. Judges were told about the different prize structures at the same time the participants were to ensure they did not disclose the prize structures to participants beforehand.[5] To avoid concerns that participants

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[5]The exception to this was one of the Thermo Fisher judges who was involved in the planning of the contest and was aware there would be two contest arms. However, she was not told who would be placed in which arm, and we have no evidence that she disclosed any information about the contest prizes to participants.

would feel betrayed if they only learned about the alternative prize structures through incidental conversations with other competitors, we disclosed the design upfront. Participants were told that the contest organizers had disagreed over the optimal prize structure and, as a result, had decided to randomly divide participants into two separate and equally sized groups with distinct prize structures. They were also assured that they would only be judged relative to others facing the same prize structure and therefore would only be competing with half of the total participant pool.

While we felt it was necessary to disclose the two prize regimes to all participants before the contest, by doing so, we risked upsetting participants who would have preferred the alternative prize structure to the one they were assigned. If this disclosure caused participants to under-invest in the contest, this could bias our estimates. We do not think this occurred in our setting for several reasons. First, when participants signed up to participate, they were explicitly told the prize structure had not been announced to ensure that they did not sign up with a particular expectation in mind. Moreover, both contest arms offer substantial prizes.[6] Second, we had zero participants complain about the prize structure they were placed in. Third, we find the prize structure the majority of participants report preferring in the post-contest survey led to worse performance than the alternative. Thus, if under-investment due to dissatisfaction with the prize structure is occurring, it is working against our findings rather than biasing our findings upwards.[7]

Participants were instructed to turn in their complete or incomplete computer scripts, written explanations, and any other non-script output by the end of the competition deadline in order to be eligible for a prize. Contest submissions were judged by six industry experts, including high-level managers at Thermo Fisher, Teradata (a software company headquartered in San Diego, California), and computer science faculty who actively consult with technology companies in the Baja region. Submissions were judged on a 5-point scale of

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[6]First place in the multiple prize arm is equal to about 31% of the annual salary of full-time employed computer scientists in the region.

[7]Moreover, we do not find differences in the quantity of output or in the likelihood that any effort is put into producing output between the two arms. This further minimizes our concern that the disclosure is biasing our findings.

across five, equally weighted categories: novelty relative to existing products on the market, functionality, user friendliness, the scope of use cases, and the degree to which it addresses the innovation challenge. A detailed description of the scoring categories and criteria is provided in section A.1.2.

All submissions were reviewed by 3 of the 6 judges to whom they were randomly assigned. To ensure comparability of judge rankings across prize structures, all submissions were pooled before being randomly assigned to judges. Judges were blinded to all information about the incentive structure under which proposals were submitted, which allows us to analyze the quality of innovations across contest arms. As advertised to participants, awards were determined by rank within each study arm.

Our experiment design allows us to control for selection into contest participation based on prize structure. In addition to deciding whether to enroll in the competition prior to prize structure randomization, all participants were required to decide whether they would like to compete as a team or as an individual before prize structures were allocated. They also completed a pre-contest survey under the same conditions. This timing ensures the following three features in our empirical analysis: 1) we are able to observe differences in effort and performance across prize structures among statistically identical populations; 2) our measures of participant characteristics are not biased by the experimental treatment; and 3) selection into teams is not affected by the prize structures.

A.1.2 Experiment Documents

Contest Promotion Text. The following text was used in flyers and emails used to promote the contest. Flyers and emails contained the text in Spanish and in English. The flyer text was also included on the contest webpage through which all participants were required to sign-up.

Promotion Email Text

Dear XYZ,

We are excited to announce a research study being conducted by Professors at UCSD that involves a weekend long Digital Baja Online Hackathon open to all residents of Baja California over the age of 18.

With 15,000 USD in prizes to be won, the contest offers participants the opportunity to propose and work towards the development of a technology that will improve healthcare in Mexico!

Thermo Fisher is assisting in the organization and judging of the contest. While we think this is a great opportunity to use your skills for a fun and important project, participation is completely voluntary and unrelated to your work if you are a Thermo Fisher employee.

Contest details, including sign-up instructions are below.

Please share this announcement with anyone you think might be interested!

Sign-Up Deadline: April 24, 2019

Contest Start Time: April 26 at 6 pm

Submission due by: April 28 at midnight

Location: Wherever you are most creative!

Sign-Up and Additional Contest Information:

Promotion Flyer Text

Digital Baja Online Hackathon!

Weekend Long Hackathon as part of a research study to better understand what motivates participation in these types of activities.

With $15,000 in prizes to be won, this contest offers participants the opportunity to propose and work towards the development of a technology that will improve healthcare in Mexico! For more information and to sign-up to participate, go to: Contest URL

Contest Rules. All individuals who signed up to participate in the contest as a team member or independently were emailed the following contest rules in Spanish and English at the start time of the innovation contest (6 pm on a Friday). The contest rules were also posted on the DevPost host pages, and on the contest webpage through which all participants were required to sign-up.

Who is eligible to participate?

Any resident of Baja California over the age of 18 is eligible to participate in the contest.

Who is eligible to win the contest?

You must sign up for the contest by filling in the participant survey and confirming your eligibility and willingness to participate by April 24 at midnight. To complete the sign-up process, visit: (*contest webpage*). Everyone who signs-up for the contest by the sign-up deadline must submit a project in compliance with the rules outlined herein to be in consideration for prize money.

Where will participants work on their projects?

This is a fully digital contest, so all work will be done remotely and submissions will be made online through a link provided to participants after the sign-up deadline. Participants can work on their solutions wherever they are most productive. Submissions require access to the internet.

Project requirements:

- Project ideas must be the original work of the submitters

- If participants' solutions uses someone else's technology, participants must make reference to this and, in the case of proprietary technology must receive permission from the owner to use it.

- Projects that violate the copyright, trademark rights, patent rights, or any other intellectual property rights of a third party will be disqualified.

- Projects that are deemed to include offensive, inappropriate, or illegal content will be disqualified

- Projects can be submitted by an individual or teams of 2 to 3

How will contest winners be selected?

Prizes will be awarded to projects with the highest scores from our panel of expert judges based on the following equally weighted factors: functionality, user friendliness, wide scope of use cases, novelty, addresses contest problem. Winners will be informed of their prize by email.

Contest dates and times:

April 24, 2019	Midnight	Deadline to sign-up for contest
April 26, 2019	6:00 PM	Contest problem is announced, contest begins
April 28, 2019	Midnight	Deadline to submit a project for consideration by judges
May 22, 2019		Contest winners will be informed of their winning

What can participants do with my project after the contest is over?

It's totally up to them! Participants retain all intellectual property rights over their submissions. The contest judges have signed an agreement to respect these rights.

What if something unexpected happens?

If something unforeseen occurs that affects the integrity of the contest, either during the contest sign-up period, the contest, or while judges are evaluating projects, we reserve the right to make changes to the contest timeline and submission requirements.

Contest Instructions. All individuals who signed up to participate in the contest as a team member or independently were emailed the following instructions in Spanish and English at the start time of the innovation contest (6 pm on a Friday). Instructions were also posted on the contest DevPost host pages. Participants in the winner-takes-all contest arm received the italicized prize information, and those in the multiple prize contest arm received the prize information in bold text. Otherwise, the information provided to participants in each arm was identical.

Dear Digital Baja Hackathon Participant,

Thank you for your interest in participating in the first ever Digital Baja Hackathon! We are thrilled to have participants like you working on a real world and important problem. Below we have provided you with details on the specific contest problem we would like you to work on, the contest prize structure, and instructions on how to submit your project.

Contest Problem: Mexico has many small health care providers and research and clinical laboratories that, on their own, cannot afford expensive equipment that would allow them to provide the highest quality care possible. We believe that the proliferation of digital and cloud technologies can help to solve this problem. We are asking you to show us how you think these technologies can be used to support access to high-quality medical equipment even for these small health care providers and labs.

Contest Prize Structure: As we could not agree on what the best prize structure for hackathons is, we have divided participants into two separate groups with two separate prize structures, each totaling $15,000! Importantly, submissions within each prize structure will only be judged relative to others in the same prize structure and this means you will only be competing with half of the contest participant pool! *You have been randomly assigned into a winner takes all prize structure with a single first place prize of $15,000!* **You have been randomly assigned into a prize structure with multiple winners in which first prize will be $6,000, second prize will be $3,000, third prize will be $1,500, 4th place will receive $900, and those who place in the 5th-10th place will receive $600!**

Submission Instructions: Please submit any computer script through the following DevPost link: . Please submit any written explanations or any other non-script output to . Please submit any and all output, even if it is incomplete.

Remember that the deadline for contest submissions is Sunday, April 28 at 11:59 pm! We look forward to seeing what you come up with!

Sincerely,

Your Digital Baja Hackathon Organizers!

Pre-Contest Survey Questions. Each individual who signed up to participate in the contest as a team member or independently was required to complete all pre-contest survey questions. In order to require this completion in compliance with IRB, participants were informed that their survey responses would be linked to their contest performance through their anonymous contest ID and that this data would be used for research undertaken at UC San Diego but not shared with Thermo Fisher or any other organization or individual. Moreover, all participants were informed from the outset that they would not be able to remove their data once they had completed their contest sign-up. This ensured that we had baseline information on all participants even if they never submitted a proposal for evaluation by our panel of judges.

The survey was offered in English and Spanish, and was completed through Google Forms. While we have reproduced the skip codes in our survey in the transcript below, this process was automated in the electronic version of our survey.

Questions 5 and 9 were intended to measure participant confidence levels. We included these questions in order to test heterogeneity in the effects of an information treatment that we had planned to run but were unable to due to sample size constraints. The details of our information treatment can be found in our RCT pre-registry (https://www.socialscienceregistry.org/trials/4026).

1. Contest ID (do not use your legal name, this is to allow us to link your survey responses to your contest performance)

2. Employment Status

   (a) Student

   (b) Full time employee

   (c) Part time employee

   (d) Self-employed

   (e) Unemployed

(f) Retired

3. Highest level of education

   (a) Less than high school

   (b) High school

   (c) Some college or vocational training

   (d) Bachelor's

   (e) Master's

   (f) PhD

4. Areas of expertise (either through experience or formal education). Check all that apply.

   (a) Desktop software development

   (b) Ecommerce development

   (c) Game development

   (d) Mobile development

   (e) QA & Testing

   (f) Scripts & Utilities

   (g) Web Development

   (h) Web & Mobile Design

   (i) Other – Software Development (Specify)

5. Relative to people with similar expertise as yourself, how would you rank your skill sets on a scale of 0-10 where zero is lower skills than everyone, 10 is better skills than everyone, and 5 is average?

6. Number of contests/hackathons previously participated in (if 0, proceed to question 11; if more than 0, proceed to question 7)

7. Have you ever placed first in an innovation contest/hackathon? If yes, how many times?

8. What is the highest rank you've achieved in prior innovation contests/hackathons you've participated in?

9. Relative to people you have competed against in these contests, how would you rank your skill sets on a scale of 0-10 where zero is lower skills than everyone, 10 is better skills than everyone, and 5 is average?

10. Why have you chosen to sign up to participate in this contest? (check all that apply)

    (a) Prize money

    (b) Develop my skills

    (c) Have fun working on the problem

    (d) Try something new

    (e) Exposure to Thermo Fisher

    (f) Exposure to UC San Diego

    (g) Exposure to judges

    (h) Build my CV

    (i) Other:

11. Choose which of the following gamble you prefer. In all instances, you have a 50% chance of receiving the low payoff, and a 50% chance of receiving the high pay-off. Answer carefully, a random 30% of respondents will receive the pay-off from their selected gamble.

Choice (50/50 Gamble)	Low Payoff (in USD)	High Payoff (in USD)
Gamble 1	16	16
Gamble 2	12	24
Gamble 3	8	32
Gamble 4	4	40
Gamble 5	0	48

12. As in the previous question, choose which of the following gamble you prefer. In all instances, you have a 50% chance of receiving the low payoff, and a 50% chance of receiving the high pay-off.

Choice (50/50 Gamble)	Low Payoff (in USD)	High Payoff (in USD)
Gamble 1	10	10
Gamble 2	6	18
Gamble 3	2	26
Gamble 4	-2	34
Gamble 5	-6	42

13. Gender

    (a) Female

    (b) Male

    (c) Other

    (d) Prefer not to answer

14. Age

    (a) 18-24

    (b) 25-34

    (c) 35-49

    (d) 50-59

    (e) 60-69

    (f) 70+

Post-Contest Survey Questions. Following the contest deadline and before the contest winner(s) were announced, all participants were asked to complete a post-contest survey. Completion of this survey was voluntary, participants were told their responses would be linked to their pre-contest survey responses and contest performance; and that their responses would also be used to better understand how to run effective innovation contests. The survey was offered in English and Spanish, and was completed through Google Forms. While we have reproduced the skip codes in our survey in the transcript below, this process was automated in the electronic version of our survey. Those redirected to section 2 were also asked to complete section 3 upon completing section 2.

In total, 58 individuals completed the survey, 67% of whom submitted a project for evaluation by the judges (compared to 4% among those who did not complete the survey). Thus, survey completion was higher among participants more engaged in the contest.

1. Contest ID:

2. As you know, we decided to split the contest into two separate competitions each with different prize structures.

   As a reminder, you were assigned a prize structure with multiple winners in which first prize will be $6,000, second prize will be $3,000, third prize will be $1,500, 4th prize will be $900, and those who place in the 5th-10th place will receive $600 OR a prize structure with a single prize of $15,000 for the first place submission.

   Participants in the other competition were assigned a prize structure with a single prize of $15,000 for the first place submission OR with multiple winners in which first prize will be $6,000, second prize will be $3,000, third prize will be $1,500, 4th prize will be $900, and those who place in the 5th-10th place will receive $600. Would you have put more, less, or the same amount of effort into the contest if you were assigned to the competition with the other prize structure?

   (a) More effort

    (b) Less effort

    (c) The same amount of effort

3. Please tell us what you think the best prize structure for an innovation contest is from the following list of options.

    (a) Single prize for the best submission

    (b) Multiple prizes for many of the top submissions

    (c) A prize for everyone who submits

    (d) Other (please explain)

4. What was the most important factor in determining your participation in this contest?

    (a) The contest prizes

    (b) The networking and exposure opportunities

    (c) Personal challenge

    (d) Other: (Please explain)

5. When did you start working on your hackathon project?

    (a) Friday evening

    (b) Friday night

    (c) Saturday morning

    (d) Saturday afternoon

    (e) Saturday evening

    (f) Saturday night

    (g) Sunday morning

    (h) Sunday afternoon

    (i) Sunday evening

(j) Sunday night

(k) I never began working on the project

6. Did you submit a project for consideration by hackathon judges?

   (a) Yes (If yes, go to section 3)

   (b) No (If no, go to section 2)

   Section 2

7. Why did you decide not to submit a project for consideration by the judges? Check ALL options that apply:

   (a) I did not have enough time to dedicate to the project due to (check all that apply):

      i. Competing work obligations

      ii. Competing personal obligations

      iii. The project proved more difficult than I had expected.

   (b) My project was incomplete, and as a result, I did not think it was good enough to submit

   (c) I completed my project but did not think it was good enough to submit

   (d) I was worried about the judges thinking poorly of my submission

   (e) I did not think I could win a prize in the contest so decided not to spend time on it

   (f) I lost interest in the contest

   (g) Other: (Please explain)

8. If you had submitted a project, how likely do you think you would have been to win a prize?

   (a) 0%

   (b) 1-15%

   (c) 16-25%

(d) 26-35%

(e) 36-50%

(f) 51-60%

(g) 61-70%

(h) 71-80%

(i) 81-90%

(j) 91-99%

(k) 100%

9. Do you have suggestions for how the hackathon could have been organized differently to convince you to submit a project for consideration by the judges? (open-ended)

Section 3

10. How much time did you spend working on the hackathon problem

(a) 0 hours

(b) 1-3 hours

(c) 4-7 hours

(d) 8-10 hours

(e) 11-15 hours

(f) 16-20 hours

(g) 21-26 hours

(h) 27-32 hours

(i) 32-40 hours

(j) More than 40 hours

11. Do you think you made the right decision in signing up for the hackathon?

(a) Yes

(b) No

12. What do you think your chance of winning a prize in the contest is (if you did not submit a project to the hackathon, choose 0

(a) 0

(b) 1-15

(c) 16-25

(d) 26-35

(e) 36-50

(f) 51-60

(g) 61-70

(h) 71-80

(i) 81-90

(j) 91-99

(k) 100

13. How would you rate your experience with the hackathon? (Scale from 1-7)

14. Would you consider participating in another hackathon?

(a) Yes

(b) No

15. Please provide us with any suggestions for how we could improve the hackathon. (open-ended)

A.2   Tables Appendix

Balance Checks for Experimental Internal Validity. To verify that our randomization was successful at assigning statistically identical populations into the single and multiple prize structures, we compare participant mean demographics and characteristics in Table A.1. These mean comparisons confirm that there are no statistically significant differences in mean participant observables by treatment group. As an alternative test of randomization success, Table A.2 analyzes whether the joint relationship between participant demographics and characteristics and treatment assignment is zero, as suggested by Bruhn and McKenzie (2009). In particular, we regress the variables presented in Table A.1 on treatment status and run a test for joint orthogonality. Table A.2 demonstrates both that no single participant observable is correlated with treatment status, and that the variables are not jointly related to treatment status (p-value=0.995). Combined, Tables A.1 and A.2 provide strong evidence that participants were randomly assigned into innovation contest prize structures.

Table A.1: Mean Demographics and Characteristics by Treatment Group

	Multiple Prize	One Prize	p-value of difference
Student	0.412	0.500	0.298
	(0.059)	(0.060)	
Employed	0.444	0.366	0.347
	(0.059)	(0.058)	
Female Participant/Group Member	0.212	0.242	0.681
	(0.051)	(0.053)	
Age Range	1.846	1.773	0.607
	(0.109)	(0.091)	
Highest Level of Education	3.697	3.694	0.989
	(0.107)	(0.138)	
Signed Up as Team	0.288	0.303	0.850
	(0.056)	(0.057)	
Any Prior Contest Experience	0.378	0.333	0.589
	(0.060)	(0.058)	
Number of Unique Areas of Relevant Expertise	3.000	2.848	0.672
	(0.259)	(0.245)	
Risk Preferences (Average within Teams)	2.886	2.851	0.875
	(0.153)	(0.165)	
Observations	66	66	

Notes: For team participants, demographics are averaged across teams except for the female variable which is equal to one if any team member is a female. For team characteristics, risk preferences is equal to the average of individual responses, number of areas of relevant expertise is equal to a count of the non-overlapping areas of expertise among team members, and prior contest experience as equal to one if any team member had previously participated in a contest. The statistics reported in the p-value of difference column are the p-values from tests of equality between the single prize and multiple prize contest arms. Standard errors are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table A.2: Omnibus Test of Random Assignment Success

	Treatment Assignment
Student	0.063
	(0.167)
Employed	-0.044
	(0.145)
Female Participant/Group Member	0.012
	(0.123)
Age Range	-0.009
	(0.077)
Highest Level of Education	0.019
	(0.051)
Signed Up as Team	0.022
	(0.114)
Any Prior Contest Experience	-0.046
	(0.100)
Number of Unique Areas of Relevant Expertise	-0.007
	(0.025)
Risk Preferences (Average within Teams)	0.002
	(0.037)
Omnibus p-value	0.995
Observations	132
R-squared	0.013
Mean dep var	0.500

Notes: The Table presents regression coefficients from a regression of participant characteristics on prize arm assignments. For team participants, demographics are averaged across teams except for the female variable which is equal to one if any team member is a female. For team characteristics, risk preferences is equal to the average of individual responses, number of areas of relevant expertise is equal to a count of the non-overlapping areas of expertise among team members, and prior contest experience as equal to one if any team member had previously participated in a contest. The Omnibus p-value reports the p-value from testing whether the sum of coefficients reported in the table is equal to zero. Standard errors are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

A.3   References

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