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The impact of innovation contest briefs on the quality of solvers and solutions

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ABSTRACT

As firms increasingly adopt online contests to improve their innovation projects, research is needed to determine which design factors make a contest successful. We examine the effects of the innovation contest brief, the description of the problem and the requirements for the potential solutions on contest performance. We focus on the length and readability of the brief and test both their effects on contest performance with a dataset containing almost 4000 online contests. Both brief readability and brief length are found to have direct and indirect effects on contest performance, and their indirect effects are determined by the effects on the number of high-skilled and low-skilled solvers that a contest attracts. Furthermore, the combined effects of both brief characteristics are positive, and these effects increase as the brief becomes more readable and longer. Finally, we find that both high-skilled and low-skilled solvers can submit high-quality solutions, but the likelihood of this is significantly higher for high-skilled solvers. This study provides clear evidence that briefs affect contest performance, making them an important element in the design of innovation contests.

1. Introduction

Due to rapid globalization and advances in network technologies, firms and individuals are increasingly connected, making it much easier to exchange ideas. In addition to this trend, more firms are reaching out to external parties to gather input that is useful for their innovation projects (Huizingh, 2011). One way to do so is through innovation contests (Boudreau and Lakhani, 2013). Since innovation contests induce competition among solvers and award only the best solutions (Terwiesch and Xu, 2008), innovation contests can efficiently and economically provide solutions for innovation problems (Garcia Martinez and Walton, 2014; Natalicchio et al., 2017). Indeed, by involving solvers external to the firm, firms can extend the breadth of their information sources (Ferrerías-Méndez et al., 2016), which increases the probability of finding valuable information and thus successful innovations. Many well-known firms, such as Dell, Best Buy, BBC, CNN, BMW, and Adobe, have adopted innovation contests to generate novel ideas (Huang et al., 2014).

Innovation contests involve several steps. A firm (also known as the “seeker”) searching for solutions to an innovation problem creates a contest brief, which is a description of the problem and the requirements for potential solutions. Then, the seeker determines the other

contest characteristics, such as the award(s) and the contest duration, and posts the contest on either its own website or a third-party website that acts as a platform for innovation contests. Examples of well-known online innovation contest platforms include 99designs (en.99-designs.nl) and Logomyway (www.logomyway.com) for design projects and Topcoder (www.topcoder.com) and CodeChef (www.codechef.com) for programming projects. Interested “solvers” can access the contest and submit their solutions. During this process, seekers can rate the quality of the solutions according to their preferences. When the contest is over, the seeker selects one or more high-quality solutions to award. Hence, to obtain high-quality solutions from the solvers, the seeker should try to motivate solvers in the contest brief. The goal of this paper to assess the effect of the contest brief on contest performance.

To generate high-quality solutions, an innovation contest must be sufficiently attractive to solvers to induce them to invest their time and effort. Motivating solvers is vital to designing a successful innovation contest (Natalicchio et al., 2014). Solvers can be motivated by various factors, including the opportunity to express creativity and competence, a sense of accomplishment, the probability of winning monetary awards, status within communities, and/or career opportunities (Deci and Ryan, 1980; Vallerand, 1997). Previous studies of innovation

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contests provide many insights into whether and how the contest awards (Liu et al., 2014; Terwiesch and Xu, 2008; Toubia, 2006), the number of solvers (Boudreau et al., 2011; Che and Gale, 2003; Fullerton and McAfee, 1999), feedback from the seeker (Jung et al., 2010; Vidal and Nossol, 2011), the solvers' submission behaviours (Bockstedt et al., 2016), and cultural factors (Bockstedt et al., 2015) affect solver success, and contest performance. Thus, from the seeker's perspective, studies on innovation contests have produced many guidelines for designing successful contests. However, previous research has neglected the effect of the contest brief.

The contest brief presents the contest details and explains the seeker's requirements and objectives to the solvers. The brief usually includes the project goal, a ranking of relevant project features, the problem scope, the solution scope, resource constraints, and evaluation criteria (Hey et al., 2007; Lüttgens et al., 2014). It is challenging for the seeker to specify the problem (Sieg et al., 2010), and this specification largely determines the extent to which the seeker can crowdsource this problem (Afuah and Tucci, 2012). The brief of an innovation contest is an important information source that a seeker provides to potential solvers, and it can affect solvers' behaviours and contest outcomes. For example, a well-formulated contest brief can reduce solver uncertainty and motivate solvers to participate (Pollok et al., 2019). With the development of technology in natural language processing, analyses can be performed to determine text characteristics indicating writing styles (Smedt, 2013), such as polarity (the extent to which a text is positive or negative), subjectivity (the extent to which a text is objective or subjective), and modality (the extent to which auxiliary verbs and adverbs are used to express uncertainty). To the best of our knowledge, no paper links these characteristics of briefs to contest performance and empirically tests these effects. In this paper, we focus on two text characteristics of contest briefs—namely, readability and length—and propose and test whether and how both characteristics of the contest brief affect contest performance (see Fig. 1). The readability and the length of contest briefs are highlighted for several reasons. First, compared to other text characteristics, readability has been studied repeatedly in other contexts and found to be a key factor (see below). We can safely develop corresponding hypotheses based on readability research. Second, both the readability and length of briefs can be reliably measured. Third, seekers can understand and influence the readability and length of briefs, and thus, they can apply the insights derived from this study to improve contest performance.

Ultimately, contest performance is conceptualized as the number of high-quality solutions a contest receives, but we suggest that this relationship can be mediated by the number of solvers who submit a solution to the contest. Because the brief can have different effects on the ability to attract different kinds of solvers, we distinguish between the number of high-skilled and low-skilled solvers submitting a solution to the contest.

We test the proposed relationships (see Fig. 1) with data from an innovation contest platform for design projects. The database contains 3931 contests, 28,325 solvers, 591,212 observations of solution submitting, and 319,931 observations of solution scoring. We use scores from the Flesch Reading Ease (Flesch, 1948) and Flesch-Kincaid Grade Level (Kincaid et al., 1975) to quantify the readability of the contest

brief and use the number of words to measure the length of the contest brief. Controlling for the effect of other contest design characteristics, the results of the negative binominal regression, zero-inflated negative binominal regression, and path analysis reveal the following:

1. Both brief readability and brief length directly influence contest performance.
2. Both brief characteristics indirectly influence contest performance through their effects on the number of high-skilled and low-skilled solvers.
3. The combined effects of both brief characteristics suggest that a contest with a long and easy-to-read brief will attract more high-quality solutions.
4. The combined effects of both brief characteristics increase as the brief becomes more readable and longer.
5. Both high-skilled and low-skilled solvers can submit high-quality solutions, though the likelihood of this is significantly greater for high-skilled solvers.

Our findings suggest that the contest brief gives the seeker an important means to leverage contest performance. Contests with long and easy-to-read briefs tend to receive more high-quality solutions. Moreover, along with well-studied characteristics such as the awards, the brief is a useful tool that can attract and motivate potential solvers to join a contest. Our findings show that different briefs attract different kinds of solvers in terms of their skill level. High-skilled solvers have the ability to develop and submit high-quality solutions. Low-skilled solvers may provide solutions of lower quality than high-skilled solvers on average. However, the range of different solutions may increase by involving low-skilled solvers. Low-skilled solvers can suggest solutions with greater variance in quality, but these can include several high-quality solutions (e.g. (Füller et al., 2017)). Thus, the seeker of a contest can proactively attract high and low-skilled solvers by deliberately developing a brief with the proper level of readability and/or length that aligns with the goal.

We structure the remainder of this paper as follows: In Section 2, we review the relevant literature and discuss our conceptual model and hypotheses. In Section 3, we detail the data and estimation strategies. We report the empirical results in Section 4 and discuss the contributions and managerial implications of the study in Section 5.

2. Literature and hypotheses

2.1. Readability of briefs

Readability refers to the characteristics that make a text comparatively easier to read. Text elements that affect readability include content (e.g., propositions, organization, and coherence), style (e.g., semantic and syntactic elements), design (e.g., typography and illustrations), and structure (e.g., chapters, headings, and navigation) (Gray and Leary, 1935). Cognitive theorists and linguists have long tried to develop practical methods to quantify the effects of these factors on overall readability. However, these methods, except for methods related to writing style, are not applicable when the readers have different reading skill levels, (DuBay, 2004). Therefore, in this study, we focus on readability in terms of writing style and define *readability* as the ease of understanding or comprehension of a text due to the style of writing (Klare, 1963). This definition suggests that seekers can influence the readability of their contest brief by changing its writing style. A text is more readable if, for example, its average sentence length (in words) is shorter, the percentage of easy words is higher, and/or it contains more explicit sentences (Gray and Leary, 1935). The readability of a text can be measured numerically using various formulas. The most tested, used, and reliable of these is the classic Flesch Reading Ease formula and its variant for determining reading grade (Chall, 1958; DuBay, 2004; Klare, 1963).

Fig. 1. Research framework.

A brief that is easier or more difficult to read may be attractive to solvers with different skill levels. This effect may be due to the motivation derived from the interaction between the solvers and the briefs. Innovation contests offer a particularly rich context from which solvers can derive intrinsic and extrinsic motivation (Hjalmarsson et al., 2017), and the literature indicates that solvers are intrinsically and extrinsically motivated (Roberts et al., 2006; Vidal and Nossol, 2011). On the one hand, extrinsic motivation may be derived from external factors such as the monetary award offered by the innovation contest, which may or may not be equally attractive to low- and high-skilled solvers (Roberts et al., 2006; Terwiesch and Xu, 2008). On the other hand, people have a basic need to be competent (White, 1959) and are intrinsically motivated to engage in challenging activities because they seek to meet this basic need (Deci and Ryan, 1985). Others define intrinsic motivation as a type of subjective experience that occurs when people perform an activity (Csikszentmihalyi, 1988). People experience these feelings only if they have the ability to persevere through the challenge (Eccles and Wigfield, 2002). To achieve this state and these feelings, there must be a balance between the challenge level of the contest and the skill level of the individual (Csikszentmihalyi, 1975). High-skilled (low-skilled) solvers will experience such feelings when they are confronted with a greater (smaller) challenge. When low-skilled solvers are confronted with a great challenge, they may feel anxiety rather than motivation (Nakamura and Csikszentmihalyi, 2014). Thus, people can be intrinsically motivated to engage in an activity due to their need for a sense of accomplishment or competence (Vallerand et al., 1993). This reasoning suggests that both high-skilled and low-skilled solvers can be intrinsically motivated by challenging tasks, as long as the level of challenge is an appropriate match with the solver's skill level.

The readability of briefs determines the setting, which subsequently determines whether the solvers will derive more or less intrinsic motivation. An innovation contest with a difficult-to-read brief can be regarded as a highly challenging task. Thus, high-skilled solvers will be more likely to regard such a contest as a challenge that matches their ability, and they will be more attracted and intrinsically motivated to join such a contest. Therefore, a contest with a less readable brief may attract more highly skilled solvers. In contrast, low-skilled solvers are more likely to consider a contest with a difficult-to-read brief as a challenge that is beyond their ability. They may feel that they would be less likely to derive a sense of accomplishment or competence by joining such a contest. Therefore, contests with less readable briefs will attract fewer low-skilled solvers.

Briefs may be less readable due to the complexity of the project, but it could also be the result of seekers not knowing exactly what they want. In such cases, contests with less readable briefs provide solvers with a larger solution space, in which solvers may feel freer to develop solutions. As a consequence, contests with less readable briefs will be more attractive to high-skilled solvers because these contests provide them with a great opportunity to exploit their skills and preference.

Combining both arguments, we formulate the following hypotheses:

Hypothesis 1. Innovation contests with less readable briefs attract more high-skilled solvers.

Hypothesis 2. Innovation contests with less readable briefs attract fewer low-skilled solvers.

In addition to having an effect on the number of solvers, readability may also directly affect the number of high-quality solutions submitted to a contest. Compared with the traditional innovation processes used in organizations, solvers who enter innovation contests are geographically and hierarchically decentralized and physically and cognitively independent (Bayus, 2013). For a seeker to organize a successful contest, solvers must be fully informed by relevant knowledge and information (Lakhani et al., 2012). The brief the seeker provides at the beginning of an innovation contest is often the only source of

information on the innovation problem that is available to solvers. The brief clarifies the objective of the project, the environment in which the solutions will be used, and the criteria for assessing the solutions. Innovation contest platforms tend to stress that seekers should provide detailed briefs to attract the highest-quality solutions. We conjecture that if a brief is more readable, its message will be easier to understand by solvers, which will help solvers develop high-quality solutions. Thus, contests with more readable briefs will receive more high-quality solutions. We formulate the following hypothesis on the direct effect of the readability of the brief:

Hypothesis 3. Innovation contests with more readable briefs receive more high-quality solutions.

2.2. Length of briefs

In addition to readability, another characteristic of the brief that the seeker can determine is its length. The length of a text is often regarded as an important dimension of page complexity (Geissler et al., 2001). More text means a greater density of information cues in the task stimulus, and task stimuli with greater density of information cues tend to be perceived as more complex (Nadkarni and Gupta, 2007). As we discussed above, the brief is the main information source for solvers developing solutions. The solver reads the brief to be able to develop high-quality solutions and ultimately, to win the contest. Therefore, solvers will examine the text for its informative value and utility. Complex cues make it more difficult for solvers to reach their goal, and thus, a solver may not be willing to invest extra effort to process these cues (Wolfenbarger and Gilly, 2001). Previous research has found that as users are less satisfied with a web page with longer text (Nadkarni and Gupta, 2007), they move away from such a stimulus and stop browsing the web page (Deng and Poole, 2010). Before solvers reach the point at which they are ready to develop a solution, they need to invest effort in processing the brief and finding useful information. Longer briefs require them to invest more effort. This extra mental resource requirement may make them less satisfied, which, in turn, will make the contest less attractive to solvers. Thus, all else being equal, longer briefs will be less attractive to solvers. Therefore, we posit the following:

Hypothesis 4. Innovation contests with longer briefs attract fewer high-skilled solvers.

Hypothesis 5. Innovation contests with longer briefs attract fewer low-skilled solvers.

However, if solvers decide to join a contest and start developing and submitting solutions, a brief with a long text can be helpful since the brief provides solvers with key information about the innovation project and the requirements for qualified solutions. The longer the brief is, the more detailed and complete the information, which makes it easier for solvers to develop high-quality solutions. Thus, contests with longer briefs are likely to receive more high-quality solutions. In line with this reasoning, we propose the following hypothesis on the direct effect of the length of the brief:

Hypothesis 6. Innovation contests with longer briefs receive more high-quality solutions.

2.3. Solvers and contest performance

In innovation contests, solvers are expected to develop solutions. The relationship between the number of solvers and contest performance has been studied extensively. Various studies from different perspectives propose mechanisms for this relationship. Studies in economics, for example, suggest that a larger number of solvers implies lower contest performance because a large number of solvers reduces

the likelihood of any one solver winning the contest, which undermines solvers' extrinsic motivation to invest effort and lowers the overall innovation outcomes (Boudreau et al., 2011; Che and Gale, 2003; Fullerton and McAfee, 1999; Taylor, 1995; Terwiesch and Xu, 2008). In line with predictions of this effect, when more solvers are involved, fewer high-quality solutions will be generated. However, other studies view innovation contests as a search process. More solvers means a broader search for the best solution, which increases the likelihood of finding one or more very good solutions (Dahan and Mendelson, 2001; Terwiesch and Xu, 2008). Empirical studies reveal that though the number of solvers is negatively correlated with the average quality of solutions a contest receives, its negative effect on the quality of the best solution is not significant (Boudreau et al., 2011). Following these seemingly competing rationales, we conjecture that a contest with a larger number of solvers may receive solutions with a lower average quality. However, an individual's likelihood of developing a high-quality solution is not substantially undermined, so contests with more solvers will receive more high-quality solutions. Taken together, we formulate the following hypotheses:

Hypothesis 7. Innovation contests with more high-skilled solvers receive more high-quality solutions.

Hypothesis 8. Innovation contests with more low-skilled solvers receive more high-quality solutions.

Hypotheses 7 and 8 predict positive effects of both the number of high- and low-skilled solvers on the number of high-quality solutions. However, we expect the magnitude of these two effects to differ. Intuitively, high-skilled solvers are more likely to develop high-quality solutions than low-skilled solvers. Thus, the positive effect of the high-skilled solvers will be greater than that of the low-skilled solvers. Accordingly, we formulate a final hypothesis:

Hypothesis 9. The positive effect of the number of high-skilled solvers on the number of high-quality solutions is greater than that of the number of low-skilled solvers.

The framework in Fig. 2 summarizes the preceding discussion and shows the hypothesized relationships among the two characteristics of briefs (readability and length), the number of high-skilled and low-skilled solvers, and the number of high-quality solutions.

3. Data and methods

3.1. Innovation contests process and data

We obtained data from the website of a well-known innovation contest platform that has existed for over a decade. Over 200,000 solvers from across the world have helped over 50,000 entrepreneurs, small business, and non-profit organizations with design services. On this website, seekers can host contests for various kinds of design projects. The process of developing a contest on the website is as follows: First, the seeker provides the contest brief, which describes the project and the type of solutions the seeker wants. Compared to other design contest platforms, solvers using this platform are allowed to more freely formulate their briefs, which leads to diversified brief styles. This large variability in brief styles helps increase the external validity of our research. The seeker also specifies the number of awards, the monetary amount of each award, and the contest duration. During the contest, solvers who login to the platform can access the contests and freely submit solutions to contests. Solvers are allowed to submit multiple solutions to the same contest. The submitted solutions are visible to all solvers. In addition, the seeker can rate the solutions (with a score of 1–5), indicating the extent to which the seeker appreciates the solution. When a contest is over, seekers can award one or more solutions. Only a few contests (approximately ten) in our original dataset did not rate any of the solutions, and these contests were not included in our dataset.

The database we use contains 3931 contests for graphic and web design projects, 21,413 solvers, 591,212 solution submissions, and 319,931 observations of solution scoring. On average, each contest received 150 solutions.

3.2. Concept measurement and variables

Language studies provide multiple formulas for measuring the readability of a text. The most commonly used formulas are the Flesch-Kincaid Grade Level and the Flesch Reading Ease (Wang et al., 2013). Both formulas have been applied to measure the readability of online texts (Candelario et al., 2017), academic articles (Sawyer et al., 2008), and popular juvenile books (Pettis, 2008). According to both formulas, fewer words per sentence and/or fewer syllables per word indicate that a text is more readable. Readability scores are calculated with the following formulas (Flesch, 1948; Kincaid et al., 1975):

$$\begin{cases} \text{Flesch-Kincaid Grade Level} = 0.39 \left(\frac{\text{total words}}{\text{total sentences}} \right) + 11.8 \left(\frac{\text{total syllables}}{\text{total words}} \right) - 15.59 \\ \text{Flesch Reading Ease} = 206.835 - 1.015 \left(\frac{\text{total words}}{\text{total sentences}} \right) - 84.6 \left(\frac{\text{total syllables}}{\text{total words}} \right) \end{cases}$$

Both scores are negatively correlated: a lower Flesch-Kincaid Grade Level and a higher Flesch Reading Ease indicate that the text is easier to read. In this study, we use both scores to measure the readability of the contest briefs. The scores are calculated using the Python package "textstat". Furthermore, following studies on web page complexity (Geissler et al., 2001; Nadkarni and Gupta, 2007), we measured the length of the briefs by the number of words in the briefs.

We derive the skill level of solvers based on their performance in all contests in our dataset. For each solver, we have data on the number of solutions submitted and the number of solutions awarded. We calculate the ratio of awarded solutions for each solver, which equals the number of awarded solutions divided by the number of submitted solutions. To classify solvers into high-skilled and low-skilled categories, we set a threshold and specify that solvers with a ratio of awarded solutions that is smaller than (larger than or equal to) this threshold are low-skilled (high-skilled) solvers. We must balance between classifying only outstanding solvers with very high success rates as high-quality solvers and making the group of high-quality solvers too large. Therefore, we aim to label the top 10 percent of the solvers as high-quality solvers, which requires a threshold of 0.15 (see Table 1). In addition, we test our model with multiple thresholds (0.11, 0.13, 0.15, 0.17, and 0.19) to determine the robustness of our findings.¹

In the data set, 53% of the awarded solutions received the maximum score of 5, and 38% received a score of 4. We classify the solutions with a score of 4 or 5 as high-quality solutions and solutions with scores between 1 and 3 as low-quality solutions. Non-scored solutions, for which we cannot infer the quality, are classified as neither high- nor low-quality solutions.

In addition to the key variables shown in the conceptual framework, we include several control variables to account for heterogeneity at the contest level. First, there is ample evidence suggesting that contest awards determine solver motivation and contest performance (Terwiesch and Xu, 2008). Thus, we include the average award value, the number of award spots, and whether or not awards are assured to control for the effect of awards on the number of high-skilled and low-skilled solvers and contest performance. Award assured is a dummy variable that equals 1 if the seeker has guaranteed that the award will be offered to the best solution(s) regardless of its quality and 0

¹ Our dataset contains 21,413 solvers in total, and 4071 solvers have won at least once. The ratios of 0.11, 0.13, 0.15, 0.17, and 0.19 correspond to the top 9%, the top 11%, the top 12%, the top 16%, and the top 20% of the 4071 solvers, respectively.

Fig. 2. Research framework and hypotheses.

Table 1
Descriptive statistics per contest.

Variables	Mean	SD	Min	Max
Number of high-quality solutions	17.68	25.83	0	433
Number of high-skilled solvers (ratio = 0.11)	5.44	4.94	0	85
Number of high-skilled solvers (ratio = 0.13)	4.63	4.63	0	73
Number of high-skilled solvers (ratio = 0.15)	4.14	4.52	0	70
Number of high-skilled solvers (ratio = 0.17)	3.54	4.43	0	62
Number of high-skilled solvers (ratio = 0.19)	3.17	4.31	0	58
Number of low-skilled solvers (ratio = 0.11)	37.35	42.51	0	906
Number of low-skilled solvers (ratio = 0.13)	38.16	42.90	0	918
Number of low-skilled solvers (ratio = 0.15)	38.65	43.09	0	921
Number of low-skilled solvers (ratio = 0.17)	39.25	43.22	0	929
Number of low-skilled solvers (ratio = 0.19)	39.62	43.32	0	933
Flesch Reading Ease (unit:10)	6.74	0.99	2.11	9.62
Flesch–Kincaid Grade Level	7.59	2.02	2.10	21.20
Length brief (number of words/100)	5.09	3.62	0.21	48.52
Number of awards	1.32	0.80	1	13
Average awards (unit: \$)	657.04	304.06	85.71	5000
Award assured	0.31		0	1
Contest duration (unit: day)	12.13	6.46	0.16	98.74
Contest category	0.64		0	1

otherwise. Second, the solvers in contests with a longer duration have more opportunities (time) to develop high-quality solutions. Thus, we include contest duration to control for this possible effect. Third, there are two types of design contests in our data: graphic design projects and web design projects. To control for possible differences between these types of contests, we include contest category as a control variable, which equals 1 for graphic design projects and 0 for web design projects. Table 1 shows the descriptive statistics of both the key variables and the control variables. We report the correlations in Table 2. This table includes only the number of high- and low-skilled solvers based on the ratio of 0.15, but the results based on the other ratios are highly similar with the statistics shown in Table 2. Table 2 shows that, except for the correlation between the two measures of readability (the Flesch Reading Ease and Flesch–Kincaid Grade Level), the correlations among the various variables are relatively low. Using the same dependent and independent variables shown in Table 3 (see below), we applied the OLS regression and reported the VIF values for each independent variable in each equation. All VIF values are below 1.7. the correlation matrix in Table 2, and the VIF results suggest that our regression analysis does not suffer from multicollinearity.

3.3. Model and estimation

To test our hypotheses (see Fig. 2) regarding the effects of the readability and length of the briefs, we use an econometric path model with three dependent variables: the number of high-skilled solvers, the number of low-skilled solvers, and the number of high-quality solutions. Each of these variables is a so-called count variable. When modelling count variables, the Poisson distribution is the most popular

distribution. However, this distribution assumes an equal mean and variance. When modelling count variables, issues of overdispersion and zero-inflation should be considered (Hilbe, 2014). Overdispersion refers to the presence of larger variability in the data than would be expected based on a given model. In such cases, the negative binomial distribution can account for the extra variance compared with the mean. Table 1 shows that the variance in the number of high-skilled solvers, the number of low-skilled solvers, and the number of high-quality solutions is much larger than the corresponding means. Thus, the negative binomial model is more suitable than the Poisson model for our data. Zero-inflation refers to the situation in which the zero value in the data is due to two different processes. Taking the number of high-quality solutions as an example, zero values can be the result of solvers joining the contest and of solvers not joining the contest. If solvers do not join, the number of high-quality solutions is, by definition, zero. If solvers join the contest, the number of high-quality solutions is the outcome of a count process, and zero means that solvers did not submit any solutions that are scored by the seeker as high-quality. Zero-inflated models use a logit model to model the two processes and a negative binomial model or Poisson model to model the count process (Cameron and Trivedi, 2010).

To empirically determine which specification is suitable for modelling the three dependent variables, we estimate and compare four count regression models (Poisson, negative binomial, zero-inflated Poisson, and zero-inflated negative binomial), using the Bayesian information criterion, the Akaike information criterion, residual fit, and the Vuong test, if applicable (Long and Freese, 2014). Consistent with the research framework shown in Fig. 2, we select independent variables for each dependent variable. We also include control variables as independent variables. The model fit (see Appendix A) shows that the negative binomial model is preferred for modelling the number of high-skilled and low-skilled solvers, and the zero-inflated negative binomial model is more suitable for modelling the number of high-quality solutions. Thus, in the path model, we use a negative binomial model to model the number of high-skilled and low-skilled solvers and a zero-inflated negative binomial model for the number of high-quality solutions, and we estimate the three equations simultaneously. The paths are configured as they appear in Fig. 2.

4. Empirical results

In this section, we first report the path analysis results and then the marginal effects of the readability and length of the brief on the number of high-quality solutions and on the number of high-skilled and low-skilled solvers. Then, we conduct several robustness analyses to check the reliability of our findings.

4.1. Path analysis

Table 3 shows the results of the path analysis. For the identification

Table 2
Correlations between variables.

	1	2	3	4	5	6	7	8	9	10
1. Number of high-quality solutions										
2. Number of high-skilled solvers (ratio = 0.15)	0.095*** (< 0.001)									
3. Number of low-skilled solvers (ratio = 0.15)	0.242*** (< 0.001)	0.427*** (< 0.001)								
4. Flesch Reading Ease (unit:10)	0.101*** (< 0.001)	−0.075*** (< 0.001)	0.116*** (< 0.001)							
5. Flesch–Kincaid Grade Level	−0.105*** (< 0.001)	0.060*** (< 0.001)	−0.097*** (< 0.001)	−0.920*** (< 0.001)						
6. Length brief (number of words/100)	0.150*** (< 0.001)	−0.027 (0.094)	−0.085*** (< 0.001)	0.063*** (< 0.001)	0.013 (0.407)					
7. Number of awards	0.170*** (< 0.001)	0.006 (0.695)	0.086*** (< 0.001)	0.092*** (< 0.001)	−0.082*** (< 0.001)	0.009 (0.580)				
8. Average awards (unit: \$)	−0.022 (0.177)	0.114*** (< 0.001)	0.021 (0.189)	−0.118*** (< 0.001)	0.115*** (< 0.001)	0.166*** (< 0.001)	−0.376*** (< 0.001)			
9. Award assured	0.250*** (< 0.001)	−0.186*** (< 0.001)	0.156*** (< 0.001)	0.115*** (< 0.001)	−0.152*** (< 0.001)	0.068*** (< 0.001)	0.113*** (< 0.001)	−0.048** (0.003)		
10. Contest duration (unit: day)	0.073*** (< 0.001)	−0.001 (0.933)	0.139*** (< 0.001)	0.053** (0.001)	−0.051** (0.001)	0.195*** (< 0.001)	−0.045** (0.005)	0.109*** (< 0.001)	0.054** (0.001)	
11. Contest category	0.161*** (< 0.001)	0.207*** (< 0.001)	0.447*** (< 0.001)	0.128*** (< 0.001)	−0.101*** (< 0.001)	−0.138*** (< 0.001)	0.150*** (< 0.001)	−0.396*** (< 0.001)	0.075*** (< 0.001)	−0.023 (0.146)

Notes: Significant level of correlation coefficients are in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3

The effects of readability and length of briefs on contest performance: Results of the path model.

	Model 1	Model 2	Model 3
	# High-skilled solvers	# Low-skilled solvers	# High-quality solutions
Readability: Flesch Reading Ease (unit: 10)	−0.076*** (−5.109)	0.038** (3.434)	0.068** (3.134)
Length of brief (unit: 100)	−0.001 (−0.114)	−0.021*** (−5.751)	0.059*** (10.086)
Number of high-skilled solvers (ratio = 0.15)			0.021*** (3.624)
Number of low-skilled solvers (ratio = 0.15)			0.004*** (5.455)
Number of awards (centred by 1)	0.088*** (5.129)	0.125*** (6.916)	0.132*** (5.882)
Average award (unit: \$, normalized)	0.200*** (13.430)	0.229*** (15.785)	0.078** (3.060)
Award assured (0: no, 1: yes)	−0.450*** (−15.999)	0.300*** (12.246)	0.584*** (14.090)
Contest duration (unit: day, normalized)	−0.003 (−0.181)	0.115*** (9.883)	0.043* (2.068)
Category: graphic (0: web, 1: graphic)	0.674*** (22.577)	1.526*** (63.719)	0.384*** (7.877)
Constant	1.543*** (15.449)	2.159*** (28.683)	1.317*** (8.762)
Overdispersion			
Constant	−0.334*** (−27.812)	−0.391*** (−43.454)	0.048*** (33.189)
Zero-inflated			
Award assured (0: no, 1: yes)			−14.025*** (−28.430)
Constant			−2.736*** (−17.914)
Test effects of:			
Number of high-skilled solvers versus Number of low-skilled solvers			0.018** (2.882)

Notes. *t*-statistics are in parentheses. Size of the sample = 3931.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

of high-skilled and low-skilled solvers, we use the ratio threshold of 0.15, and we measure readability with the Flesch Reading Ease score. The results using lower and higher thresholds (0.11, 0.13, 0.17, and 0.19) to define the skill level of solvers and the results using the Flesch-Kincaid Grade Level to measure the readability of briefs are confirmed by those in Table 3 (see Appendix B).

Model 1 shows that the effect of the Flesch Reading Ease score on the number of high-skilled solvers is significant and negative, while the effect of brief length is very small and not significant. Thus, the results support H1 but not H4. Contests with less readable briefs tend to attract more high-skilled solvers; the length of the brief does not significantly influence the number of high-skilled solvers. Model 2 reports the estimates of the effects on the number of low-skilled solvers. The

coefficient of the Flesch Reading Ease score is significant and positive, while brief length is significant and negative, suggesting that contests with more readable or shorter briefs attract more low-skilled solvers, consistent with both H2 and H5.

Model 3 includes the results for contest performance, measured as the number of high-quality solutions. The coefficients of the Flesch Reading Ease score and brief length are both positive and significant, indicating that contests with more readable or longer briefs tend to receive more high-quality solutions. The effects of the number of low-skilled and high-skilled solvers are also positive and significant, which means that more high-skilled solvers and more low-skilled solvers both lead to an increase in high-quality solutions. We compare the magnitudes of both positive effects by determining the difference between the coefficient of “Number of high-skilled solvers” and the coefficient of “Number of low-skilled solvers” and its level of significance. The results (difference = 0.018, $t = 2.882$, $p < 0.01$) reveal that the coefficient of high-skilled solvers is significantly larger than the coefficient of low-skilled solvers. Thus, high-skilled solvers are more likely to contribute high-quality solutions than low-skilled solvers. In summary, Model 3 provides support for H3, H6, H7, H8, and H9. Fig. 3 provides an overview of all our findings.

In addition to the results shown in Fig. 3, we find multiple significant effects of the contest characteristics that are included as control variables. First, some interesting findings emerge from the control variables. The positive and significant coefficients of the number of awards (0.088***, 0.125***, 0.132***) and average awards (0.200***, 0.229***, 0.078**) used in the three models indicate that contests with more awards and higher average awards attract more high- and low-skilled solvers and subsequently, obtain more high-quality solutions. Award assured has a negative and significant coefficient in Model 1 (−0.450***) and has positive and significant coefficients in Models 2 (0.300***) and 3 (0.584***). Thus, contests that assure solvers will be awarded tend to have fewer high-skilled solvers and more less-skilled solvers and high-quality solutions. The coefficient of contest duration in Model 1 is not significant (−0.003) but positive and significant in Models 2 (0.115***) and 3 (0.043*). Thus, contests that last longer do not attract more high-skilled solvers but have more low-skilled solvers and more high-quality solutions. The positive coefficients of category graphic (0.674***, 1.526***, 0.384***) indicate that compared to contests for web design, contests for graphic design tend to have more high- and low-skilled solvers and more high-quality solutions. In Model 3, the negative and significant coefficient of award assured in the zero-inflated part of the zero-inflated negative binomial model (−14.025***) indicates that contests that ensure that solvers will be awarded are less likely to receive no high-quality solutions.

4.2. Total effects on high-quality solutions

As we proposed and tested in the previous sections, contest briefs with different writing styles attract different numbers and types of solvers in terms of their skill level, which, in turn, affects contest

Fig. 3. Results of the path model.

Fig. 4. Total Effects of Readability and Brief Length on the Number of High-Quality Solutions.

Note. “Path analysis: value” refers to the corresponding estimated elasticities or marginal effects. “Path analysis: upper” (“Path analysis: lower”) refers to the corresponding estimated elasticities or marginal effects plus (minus) two times their estimated standard errors.

performance. Because contest briefs provide solvers with useful information, brief characteristics also directly influence contest performance. Therefore, in our conceptual model, the readability and length of the brief both directly and indirectly influence the number of high-quality solutions (see Fig. 3). The combined effect has important managerial implications for how briefs should be developed to improve contest performance. However, the combined effect is not obvious because some direct and indirect effects differ in their direction. For example, the length of the brief has a direct and positive effect on the number of high-quality solutions, but it indirectly affects the number of high-quality solutions by decreasing the number of low-skilled solvers. When using linear models, researchers often report statistics such as the degree of mediation, but such statistics cannot be computed directly for the negative binomial and zero-inflated negative binomial models used in this study. Therefore, to derive the combined effects, we conduct a simulation analysis and calculate the elasticities and marginal effects (predicted change in the dependent variable after a unit change in the explanatory variable) for both brief characteristics. Appendix C describes the method used to derive the elasticities and marginal effects. We show these elasticities and marginal effects in Fig. 4.

Fig. 4 provides the following insights. First, the elasticity and marginal effect of the Flesch Reading Ease score are consistently greater than zero and increase as briefs become more readable. When the Flesch Reading Ease score is 40 (indicating a less readable brief), a 1% improvement in readability leads to a 0.3% ($0.3 \times 1\%$) change in the predicted number of high-quality solutions. When the Flesch Reading Ease score increases by 1 unit, the number of high-quality solutions increases by approximately 1.6. When the Flesch Reading Ease score is 80 (indicating a fairly easy-to-read brief), a 1% improvement leads to approximately a 0.6% ($0.6 \times 1\%$) change in the number of high-quality solutions. When the Flesch Reading Ease score increases by 1 unit, the number of high-quality solutions increases by approximately 2.3. This result shows that at higher levels of readability, further increases in readability have a higher elasticity and marginal effect (rather than a lower elasticity and marginal effect, as one may intuitively think).

Fig. 3 shows that readability influences contest performance indirectly in both a positive way and a negative way. We conclude that the negative effect of readability on contest performance is dominated by positive effects.

Second, the elasticity and marginal effect of brief length are consistently greater than zero, and they increase as briefs become longer. When a contest brief contains 1000 words, a 1% increase in word count leads to a 0.5% ($0.5 \times 1\%$) change in the number of high-quality solutions. When the number of words increases by 1 unit, the number of high-quality solutions increases by approximately 2. When a contest brief contains 3000 words, a 1% increase in word count results in a 1.7% ($1.7 \times 1\%$) change in the number of high-quality solutions. When the number of words increases by 1 unit, the number of high-quality solutions increases by approximately 6. Fig. 3 shows that brief length has both a negative indirect effect and a positive direct effect on contest performance. However, the combined effect of brief length is positive, indicating that its direct effect is larger than its indirect effects.

4.3. Direct effects on high- and low-skilled solvers

Consistent with the simulation method for calculating the total effects on high-quality solutions (see Appendix C), we derive the elasticity and the marginal effect of both brief characteristics on the number of high- and low-skilled solvers; the results are shown in Figs. 5 and 6. In Fig. 5, we find that the elasticity and marginal effect of readability on the number of high-skilled solvers is negative, and it will become more negative as the brief becomes more readable. The effect of brief length on the number of high-skilled solvers is not significant. Fig. 6 shows that the elasticity and marginal effect of readability on the number of low-skilled solvers is positive, and it will become more positive as the brief becomes more readable. The effect of brief length on the number of low-skilled solvers is negative. As the brief becomes longer, the elasticity of this effect becomes more negative, while its marginal effect tends to be less negative.

Fig. 5. Direct Effects of Readability and Brief Length on the Number of High-skilled Solvers.

Note. “Path analysis: value” refers to the corresponding estimated elasticities or marginal effects. “Path analysis: upper” (“Path analysis: lower”) refers to the corresponding estimated elasticities or marginal effects plus (minus) two times their estimated standard errors.

4.4. Robustness checks

To test the extent to which our results are dependent on the assumptions we have made, we performed four robustness checks. First, we applied lower and higher thresholds (0.11, 0.13, 0.17, and 0.19) to

determine the skill level of solvers and used the Flesch-Kincaid Grade Level to measure the readability of briefs. Then, we re-estimated the path model. The results (see [Appendix B](#)) are confirmed by comparing them with those in [Table 3](#).

In Section 4.1, we estimated the three equations simultaneously as a

Fig. 6. Direct Effects of Readability and Brief Length on the Number of Low-skilled Solvers.

Note. “Path analysis: value” refers to the corresponding estimated elasticities or marginal effects. “Path analysis: upper” (“Path analysis: lower”) refers to the corresponding estimated elasticities or marginal effects plus (minus) two times their estimated standard errors.

path model. To check the robustness of the path analysis estimates, we estimated these equations separately. Again, we use a negative binomial regression to model the number of high-skilled and low-skilled solvers and a zero-inflated negative binomial regression to model the number of high-quality solutions. We use five thresholds (0.11, 0.13, 0.15, 0.17, and 0.19) to define the skill level of the solvers, and we use the Flesch Reading Ease score and the Flesch-Kincaid Grade Level to measure readability. We again find that the estimates (see [Appendix D](#)) are consistent with their counterparts in the path analysis shown in [Appendix B](#).

Third, the combined effects of readability and brief length on the number of high-quality solutions, as shown in [Fig. 4](#), are empirically derived from the results of the path analysis, which includes the number of high-skilled and low-skilled solvers as mediators. In the robustness check, we conduct a simple zero-inflated negative binomial regression to directly relate the number of high-quality solutions to readability and brief length while excluding the number of high-skilled and low-skilled solvers. We present these results in [Appendix E](#). Again, the effects of readability and brief length are positive and significant. We also determine the elasticities and marginal effects based on this simple regression and compare them with their counterparts derived from the path analysis (see the figures in [Appendix F](#)). The magnitudes of the elasticities and marginal effects based on the simple zero-inflated negative binomial regression are almost the same as their counterparts based on the path analysis.

Fourth, we checked the model specification for the number of high-quality solutions. In the model specification shown previously, we assume brief length to have a linear effect on the number of high-quality solutions, and the results show that contests with a longer briefs receive more high-quality solutions. However, if the brief is too long, it might contain irrelevant information that does not help solvers create high-quality solutions but rather wastes their mental resources. Thus, brief length might have a nonlinear effect on contest performance. We followed the instructions in [Lind and Mehlum \(2010\)](#) and [Haans et al. \(2016\)](#) to test for this nonlinear effect. First, we included the squared term of brief length in the model for the number of high-quality solutions and tested the significance of the coefficient of the squared term. The slope at both ends of the data range should be sufficiently precipitous, and the turning point should be located within the data range. The results (see the tables and figures in [Appendix G](#)) show that if all contests are used, there is an inverted U-shaped relationship between brief length and the number of high-quality solutions. However, when we checked the marginal effect of brief length (see [Fig. 1](#) in [Appendix G](#) part 2), we found that for almost all the sample data, the relationship between brief length and contest performance is positive, and only for very high values of brief length this relationship becomes negative. When we exclude contests with a brief length longer than 2000 words and retested this nonlinear effect, we found that this inverted U-shaped relationship did not hold (see the test in [Appendix G](#) part 3). Thus, we concluded that the significance of the squared term of brief length is mainly caused by a few extreme values. Compared with the nonlinear effect of brief length, we found the linear effect to be more robust. To conclude, the results of the path analysis and the hypotheses testing were robust to various changes to the analysis approach.

5. Discussion and implications

Innovation contests are a promising mechanism for improving innovation by harnessing the expertise, creativity, and efforts of individuals external to the firm ([Boudreau and Lakhani, 2013](#)). A contest starts with a seeker formulating and articulating the innovation challenge and the nature of the desired solution. From the seeker's perspective, solvers should be well motivated and informed by the brief that describes the innovation problem. The economics, organizational behaviour, and psychology literature provides various suggestions for improving the contest design and boosting contest performance

([Adamczyk et al., 2012](#)). However, although briefs have been extensively studied in the design research field ([Hey et al., 2007](#); [Paton and Dorst, 2011](#); [Ryd, 2004](#)), much less is known about their function and relevance in innovation contests. Many online platforms used for innovation contests suggest that seekers develop detailed briefs to improve contest performance, but the mechanism underlying this positive effect has been neither detailed nor tested. The current study fills this research gap by developing a framework outlining how contest brief characteristics, namely, readability and length, affect contest performance directly and indirectly and by testing this framework with data from a large number of actual innovation contests.

Our results clearly show the importance of contest briefs. Contest brief characteristics both directly and indirectly influence contest performance. We detail five main findings. First, both brief readability and brief length have direct and positive effects on contest performance. The more readable a brief is and the more words it contains, the more high-quality solutions a contest receives. Second, both brief characteristics also indirectly influence contest performance because they affect the number of high-skilled and low-skilled solvers that a contest attracts. Briefs that are easier to read attract fewer high-skilled solvers and more low-skilled solvers. Longer briefs tend to attract fewer low-skilled solvers (the effect on high-skilled solvers is not significant). Third, the combined effects of brief readability and brief length on contest performance are both positive. Although some of the indirect effects are negative, the combined effects, which include the direct effect and all indirect effects, are positive for both brief characteristics. Fourth, the combined effects are not constant for all levels of readability and brief length. They increase with higher levels of readability and with a larger number of words in the contest brief. Fifth, high-quality solutions are submitted by both high-skilled solvers and low-skilled solvers, although we find a significantly larger effect for high-skilled solvers.

The submissions to innovation contests are visible to others, which may affect the independence of solvers and their subsequent submissions. This may cause solvers to engage in “free-riding” behaviour. However, [Bockstedt et al. \(2016\)](#) found that in “unblind” contests, solvers who have a lower position for their first submission are more likely to win the contest. Thus, although submitting early in the process may increase the risk of free-riding and problems related to intellectual property, the solvers benefit from such a “first mover advantage”. Furthermore, the platform has specific policies to protect intellectual property. Anyone (seekers or solvers) who suspects that his/her idea has been stolen during solution development can turn to the platform for help. Therefore, we think our research findings do not suffer severely from the “free-riding” issue.

5.1. Contributions to the literature

Taken together, our findings make several key contributions to the growing literature on innovation contests. First, the direct and indirect effects of contest briefs provide clear evidence that contest briefs affect contest performance. Previous innovation contest research has provided insights into how awards ([Terwiesch and Xu, 2008](#)), the number of solvers ([Boudreau et al., 2011](#)), feedback ([Ederer, 2010](#)), and cultural factors ([Bockstedt et al., 2015](#)) affect contest performance. However, little is known about whether and how contest briefs affect contest performance. We focused on two major aspects of the writing style, readability and length, and found convincing empirical evidence that both brief characteristics directly and indirectly influence contest performance. More readable and longer briefs result in more high-quality solutions; the indirect effect is determined by the effects on the number of high-skilled and low-skilled solvers. By testing both direct and indirect effects, we were able to show not only that both brief characteristics matter but also how they affect contest performance. Sometimes, the indirect effects were negative, which explains why unexpected effects may be found when researchers focus on

intermediate contest performance measures, such as the number of solvers a contest attracts, instead of on ultimate contest performance in the form of high-quality solutions. Nevertheless, for both readability and brief length, we find that the combined effect is consistently positive.

Second, the effects of high-skilled and low-skilled solvers on contest performance show that high-quality solutions can originate from both high-skilled and low-skilled solvers, which suggests a positive relationship exists between the total number of solvers and the number of high-quality solutions. This pattern echoes the parallel path effect revealed in previous research (Boudreau et al., 2011; Terwiesch and Xu, 2008). This effect indicates that as the number of solvers increases and as more solvers provide solutions for an innovation challenge, the likelihood that high-quality solutions will be submitted increases. The parallel path effect suggests that both high-skilled and low-skilled solvers can be the source of high-quality solutions. Our study provided supportive evidence, but it also showed that the positive effect of the number of high-skilled solvers is significantly greater than the effect of the number of low-skilled solvers.

Third, the combined effects of contest briefs suggest that contest performance, in terms of the number of high-quality solutions submitted, can benefit from easy-to-read and long briefs. Both findings were consistent with the rationale of the dual pathway to creativity model (Baas et al., 2013). According to this model, creative ideas can be generated through pathways related to flexibility and persistence. The persistence pathway refers to people investing their cognitive resources and systematically focusing attention and effort on the task at hand (Baas et al., 2013; De Dreu et al., 2008; Nijstad et al., 2010). Highly informative briefs, which are long and readable, enable solvers to acquire and process detailed information about the specifics of an innovation project, thereby facilitating solvers' ability to develop creative, high-quality solutions through a persistence pathway.

Fourth, our study suggested that insights from web communication studies can be extended to innovation contest research. We found evidence that how the content of a contest is presented on the web influences the behaviour of solvers and contest performance. The hypotheses that linked web page complexity to solver behaviour were based on theories and mechanisms from web communication studies. Our confirming evidence suggests that this related research can be applied to further improve our understanding of the process and effects of online innovation contests.

5.2. Managerial implications

This study highlighted several managerial implications for seekers. First, seekers should realize that the writing style of a contest brief affects potential solvers and, ultimately, contest performance. Seekers can increase the likelihood of attracting solvers of a certain skill level by developing a brief with a specific writing style. If organizers want to attract high-skilled solvers, they need to develop briefs that are more complex, technical, and less readable. If seekers want to attract more low-skilled solvers ("the crowd"), briefs should be shorter and more readable. If the main focus of seekers is on receiving high-quality solutions, a longer and more readable brief seems to be a wise choice. Second, we found evidence that both high-skilled and low-skilled solvers can submit high-quality solutions, which suggests there are two possible strategies seekers can use to attract solvers. One is by relying on high-skilled solvers. High-skilled solvers are more likely to submit high-quality solutions than low-skilled solvers. Thus, by focusing on attracting high-skilled solvers, seekers can increase the likelihood of receiving high-quality solutions without having to invest much effort in interacting with a large number of solvers. However, because solutions are developed by fewer solvers, the seeker may not benefit from the diversity of solvers. The other strategy would be to rely on low-skilled solvers by developing more readable and shorter contest briefs; seekers will receive more diversified and high-quality solutions. The downside

could be that interacting with a large group of low-skilled solvers may require more effort on the part of the seeker. Each strategy has its own advantages and disadvantages, and seekers can choose one based on their preferences.

5.3. Limitations and opportunities for further research

We should also mention that our study has a few limitations. One limitation results from how we operationalized the different styles of briefs. In this study, we focused on relatively simple and commonly used characteristics: readability and length. Both characteristics are explicit and concrete, and seekers can easily develop different briefs with different levels of readability and length. However, with the development of text mining, researchers can analyse more subtle dimensions of brief styles (e.g., polarity, subjectivity, and uncertainty) (Montoyo et al., 2012; Smedt and Daelemans, 2012; Wilson et al., 2005). Studying these dimensions may further enrich our understanding of the function of briefs in innovation contests. A second potential limitation is that we classified solvers into high-skilled and low-skilled categories. Although this classification simplifies the conceptual framework and the robustness checks show that this classification does not affect our findings, it limits our ability to precisely determine how solvers with different skill levels respond to briefs written in different styles. Additional studies might apply other measures to define the skill level of solvers and use more advanced methods (e.g., quantile regression) to study this relationship. Third, in this study, we rely on real-world innovation contests, which increases the external validity of our findings but also implies that we were not able to obtain information on the difficulty of the innovation challenges posted. It is possible that briefs that are more difficult to read make it more difficult to solve the challenges. We could partly control for this by including three award-related variables as controls in our model, but it would be interesting to test whether our findings hold for briefs with different readability levels and varying lengths describing problems with the same level of difficulty in an experimental setting. Fourth, we determined the skill level of solvers based on their performance in all contests in the entire dataset. In this way, we made maximum use of the available data to measure solver quality. However, learning effects are not accounted for. Future studies can incorporate such effects to increase our understanding of whether, how, and how fast solvers learn from seeker feedback and ratings. Finally, this study showed that high-skilled and low-skilled solvers respond differently to briefs and contest design elements (e.g., awards and contest duration; see Table 3). Boudreau et al. (2016) found that solvers with different skill levels respond differently when new solvers enter a contest. Based on such findings, future studies can further explore the effects (and underlying reasons) of various skill levels of solvers on contest performance, as well as the effects of contest design elements on the ability to attract and subsequent performance of various types of solvers.

To conclude, this study provided clear evidence that the brief—the first and often sole source of contest information for solvers—influences contest performance directly and indirectly. This study is one of the first to focus on this seemingly obvious but often-overlooked instrument, provides useful guidelines for improving contest performance and enhances our understanding of the effectiveness of online innovation contests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://>

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References

- Adamczyk, S., Bullinger, A.C., Möslin, K.M., 2012. Innovation contests: a review, classification and outlook. *Creativ. Innov. Manag.* 21, 335–360.
- Afuah, A., Tucci, C.L., 2012. Crowdsourcing as A Solution to distant search. *Acad. Manag. Rev.* 37, 355–375.
- Baas, M., Roskes, M., Sligte, D., Nijstad, B.A., De Dreu, C.K.W., 2013. Personality and creativity: the dual pathway to creativity model and a research agenda. *Soc. Personal. Psychol. Compass* 7, 732–748.
- Bayus, B.L., 2013. Crowdsourcing new product ideas over time: an analysis of the Dell IdeaStorm community. *Manag. Sci.* 59, 226–244.
- Bockstedt, J., Druhl, C., Mishra, A., 2015. Problem-solving effort and success in innovation contests: the role of national wealth and national culture. *J. Oper. Manag.* 36, 187–200.
- Bockstedt, J., Druhl, C., Mishra, A., 2016. Heterogeneous submission behavior and its implications for success in innovation contests with public submissions. *Prod. Oper. Manag.* 25, 1157–1176.
- Boudreau, K.J., Lacetera, N., Lakhani, K.R., 2011. Incentives and problem uncertainty in innovation contests: an empirical analysis. *Manag. Sci.* 57, 843–863.
- Boudreau, K.J., Lakhani, K.R., 2013. Using the Crowd as an Innovation Partner, Harvard Business Review. Harvard Business Publishing, Boston, MA, pp. 60–70.
- Boudreau, K.J., Lakhani, K.R., Menietti, M., 2016. Performance responses to competition across skill levels in rank-order tournaments: field evidence and implications for tournament design. *RAND J. Econ.* 47, 140–165.
- Cameron, A.C., Trivedi, P.K., 2010. *Microeconometrics Using Stata*, Revised Edition. Stata Press, College Station, Texas.
- Candelario, D.M., Vazquez, V., Jackson, W., Reilly, T., 2017. Completeness, accuracy, and readability of Wikipedia as A reference for patient medication information. *J. Am. Pharm. Assoc.* 57, 197–200.
- Chall, J.S., 1958. Readability: an Appraisal of Research and Application. Ohio State University, Columbus Ohio.
- Che, Y.-K., Gale, I., 2003. Optimal design of research contests. *Am. Econ. Rev.* 93, 646–671.
- Csikszentmihalyi, M., 1975. *Beyond Boredom and Anxiety*. Jossey-Bass Publishers, San Francisco.
- Csikszentmihalyi, M., 1988. The flow experience and its significance for human psychology. In: Csikszentmihalyi, M., Csikszentmihalyi, I.S. (Eds.), *Optimal Experience: Psychological Studies of Flow in Consciousness*. The Press Syndicate of The University of Cambridge, Cambridge, UK, pp. 15–35.
- Dahan, E., Mendelson, H., 2001. An extreme-value model of concept testing. *Manag. Sci.* 47, 102–116.
- De Dreu, C.K.W., Baas, M., Nijstad, B.A., 2008. Hedonic tone and activation level in the mood-creativity link: toward a dual pathway to creativity model. *J. Personal. Soc. Psychol.* 94, 739–756.
- Deci, E.L., Ryan, R.M., 1980. The empirical exploration of intrinsic motivational processes. In: Leonard, B. (Ed.), *Advances in Experimental Social Psychology*. Academic Press, pp. 39–80.
- Deci, E.L., Ryan, R.M., 1985. *Intrinsic Motivation and Self-Determination in Human Behavior*. Springer, New York.
- Deng, L., Poole, M.S., 2010. Affect in web interfaces: a study of the impacts of web page visual complexity and order. *MIS Q.* 34, 711–730.
- DuBay, W.H., 2004. *The Principles of Readability*. Impact Information, Costa Mesa, California.
- Eccles, J.S., Wigfield, A., 2002. Motivational beliefs, values, and goals. *Annu. Rev. Psychol.* 53, 109–132.
- Ederer, F., 2010. Feedback and motivation in dynamic tournaments. *J. Econ. Manag. Strategy* 19, 733–769.
- Ferreras-Méndez, J.L., Fernández-Mesa, A., Alegre, J., 2016. The relationship between knowledge search strategies and absorptive capacity: a deeper look. *Technovation* 54, 48–61.
- Flesch, R., 1948. A new readability yardstick. *J. Appl. Psychol.* 32, 221–233.
- Füller, J., Hutter, K., Hautz, J., Matzler, K., 2017. The role of professionalism in innovation contest communities. *Long. Range Plan.* 50, 243–259.
- Fullerton, R.L., McAfee, R.P., 1999. Auctioning entry into tournaments. *J. Political Econ.* 107, 573–605.
- Garcia Martinez, M., Walton, B., 2014. The wisdom of crowds: the potential of online communities as a tool for data analysis. *Technovation* 34, 203–214.
- Geissler, G.L., Zinkhan, G.M., Watson, R.T., 2001. Web home page complexity and communication effectiveness. *J. Assoc. Inf. Syst.* 2, 1–46.
- Gray, W.S., Leary, B.E., 1935. *What Makes A Book Readable: with Special Reference to Adults of Limited Reading Ability-An Initial Study*. University of Chicago Press, Chicago.
- Haas, R.F.J., Pieters, C., He, Z.L., 2016. Thinking about U: theorizing and testing U- and inverted U-shaped relationships in strategy research. *Strateg. Manag. J.* 37, 1177–1195.
- Hey, J.H.G., Joyce, C.K., Beckman, S.L., 2007. Framing innovation: negotiating shared frames during early design phases. *J. Des. Res.* 6, 79–99.
- Hilbe, J.M., 2014. *Modeling Count Data*. Cambridge University Press, New York, US.
- Hjalmarsson, A., Juell-Skielse, G., Johannesson, P., 2017. Open Digital Innovation: A Contest Driven Approach. Springer International Publishing AG, Switzerland, Cham.
- Huang, Y., Singh, P.V., Srinivasan, K., 2014. Crowdsourcing new product ideas under consumer learning. *Manag. Sci.* 60, 2138–2159.
- Huizingh, E.K.R.E., 2011. Open innovation: the state of the art and future perspectives. *Technovation* 31, 2–9.
- Jung, J.H., Schneider, C., Valacich, J., 2010. Enhancing the motivational affordance of information systems: the effects of real-time performance feedback and goal setting in group collaboration environments. *Manag. Sci.* 56, 724–742.
- Kincaid, J.P., Fishburne, L.R.P., Rogers, R.L., Chissom, B.S., 1975. *Derivation of New Readability Formulas (Automated Readability Index, Fog Count, and Flesch Reading Ease Formula) for Navy Enlisted Personnel*, Chief of Naval Technical Training. Naval Air Station Memphis, Millington, Tennessee.
- Klare, G.R., 1963. *The Measurement of Readability*. Iowa State University Press, Ames, US.
- Lakhani, K.R., Lifshitz-Assaf, H., Tushman, M., 2012. Open Innovation and Organizational Boundaries: the Impact of Task Decomposition and Knowledge Distribution on the Locus of Innovation, Harvard Business School Technology & Operations Mgt. Unit Working Paper No. 12-57; Harvard Business School Organizational Behavior Unit Working Paper No. 12-057. Harvard Business School.
- Lind, J.T., Mehlum, H., 2010. With or without U? The appropriate test for a U-shaped relationship. *Oxf. Bull. Econ. Stat.* 72, 109–118.
- Liu, T.X., Yang, J., Adamic, L.A., Chen, Y., 2014. Crowdsourcing with all-pay auctions: a field experiment on taskcn. *Manag. Sci.* 60, 2020–2037.
- Long, J.S., Freese, J., 2014. *Regression Models for Categorical Dependent Variables Using Stata*, third ed. Stata Press, College Station, Texas.
- Lüttgens, D., Pollok, P., Antons, D., Piller, F., 2014. Wisdom of the crowd and capabilities of A few: internal success factors of crowdsourcing for innovation. *J. Bus. Econ.* 84, 339–374.
- Montoyo, A., Martínez-Barco, P., Balahur, A., 2012. Subjectivity and sentiment analysis: an overview of the current state of the area and envisaged developments. *Decis. Support Syst.* 53, 675–679.
- Nadkarni, S., Gupta, R., 2007. A task-based model of perceived website complexity. *MIS Q.* 31, 501–524.
- Nakamura, J., Csikszentmihalyi, M., 2014. The concept of flow. In: Csikszentmihalyi, M. (Ed.), *Flow and the Foundations of Positive Psychology: the Collected Works of Mihaly Csikszentmihalyi*. Springer Netherlands, Dordrecht, pp. 239–263.
- Natalicchio, A., Messeni Petruzzelli, A., Garavelli, A.C., 2014. A literature review on markets for ideas: emerging characteristics and unanswered questions. *Technovation* 34, 65–76.
- Natalicchio, A., Messeni Petruzzelli, A., Garavelli, A.C., 2017. Innovation Problems and Search for Solutions in Crowdsourcing Platforms-A Simulation Approach. *Technovation*.
- Nijstad, B.A., De Dreu, C.K.W., Rietzschel, E.F., Baas, M., 2010. The dual pathway to creativity model: creative ideation as a function of flexibility and persistence. *Eur. Rev. Soc. Psychol.* 21, 34–77.
- Paton, B., Dorst, K., 2011. Briefing and reframing: a situated practice. *Des. Stud.* 32, 573–587.
- Pettis, J.E., 2008. *Grade Reading Levels of Harry Potter Books*.
- Pollok, P., Lüttgens, D., Piller, F.T., 2019. Attracting solutions in crowdsourcing contests: the role of knowledge distance, identity disclosure, and seeker status. *Res. Policy* 48.
- Roberts, J.A., Hann, I.-H., Slaughter, S.A., 2006. Understanding the motivations, participation, and performance of open source software developers: a longitudinal study of the Apache projects. *Manag. Sci.* 52, 984–999.
- Ryd, N., 2004. The design brief as carrier of client information during the construction process. *Des. Stud.* 25, 231–249.
- Sawyer, A.G., Laran, J., Xu, J., 2008. The readability of marketing journals: are award-winning articles better written? *J. Mark.* 72, 108–117.
- Sieg, J.H., Wallin, M.W., von Krogh, G., 2010. Managerial challenges in open innovation: a study of innovation intermediation in the chemical industry. *R. D. Manag.* 40, 281–291.
- Smedt, T.D., 2013. *Modeling Creativity: Case Studies in python*. Uitgeverij UPA University Press Antwerp, Brussels.
- Smedt, T.D., Daelemans, W., 2012. Pattern for Python. *J. Mach. Learn. Res.* 13, 2063–2067.
- Taylor, C.R., 1995. Digging for golden carrots: an analysis of research tournaments. *Am. Econ. Rev.* 85, 872–890.
- Terwiesch, C., Xu, Y., 2008. Innovation contests, open innovation, multiagent problem solving. *Manag. Sci.* 54, 1529–1543.
- Toubia, O., 2006. Idea generation, creativity, and incentives. *Mark. Sci.* 25, 411–425.
- Vallerand, R.J., 1997. Toward A hierarchical model of intrinsic and extrinsic motivation. In: Olson, J.M., Zanna, M.P. (Eds.), *Advances in Experimental Social Psychology*. Academic Press, Cambridge, MA, pp. 271–360.
- Vallerand, R.J., Pelletier, L.G., Blais, M.R., Briere, N.M., Senecal, C., Vallieres, E.F., 1993. On the assessment of intrinsic, extrinsic, and amotivation in education: evidence on the concurrent and construct validity of the academic motivation scale. *Educ. Psychol. Meas.* 53, 159–172.
- Vidal, J.B.I., Nossol, M., 2011. Tournaments without prizes: evidence from personnel records. *Manag. Sci.* 57, 1721–1736.
- Wang, L.-W., Miller, M.J., Schmitt, M.R., Wen, F.K., 2013. Assessing readability formula differences with written health information materials: application, results, and recommendations. *Res. Soc. Adm. Pharm.* 9, 503–516.
- White, R.W., 1959. Motivation reconsidered: the concept of competence. *Psychol. Rev.* 66, 297–333.
- Wilson, T., Wiebe, J., Hoffmann, P., 2005. Recognizing contextual polarity in phrase-level sentiment analysis. In: *Proceedings of the Conference on Human Language Technology and Empirical Methods in Natural Language Processing*. Association for Computational Linguistics, Vancouver, British Columbia, Canada, pp. 347–354.
- Wolfenbarger, M., Gilly, M.C., 2001. Shopping online for freedom, control, and fun. *Calif. Manag. Rev.* 43, 34–55.