Crowd Size and Crowdsourcing Performances in Online Ideation Contests

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***Abstract*—Does the number of participants in an online ideation contest affect its performances? We provide an answer to this question by analyzing the innovations developed in 106 ideation contests run on an online crowdsourcing platform. For each contest, we investigate the association between the number of participants and (i) the innovation performance, by identifying patented products through the US Patent and Trademark Office (ii) the process performance, in terms of time to market of the innovation (iii) the market performance, in terms of product sales. We find evidence of a negative association between the numerousness of participants and both market performance and process performance. Conversely, our results show a positive association between participants' numerousness and innovation performance. We call for a proper crowd participation design, related to the different objectives crowdsourcing activities want to achieve, from an exploration-exploitation perspective.**

Keywords—crowdsourcing; ideation contest performance; new product and service development; online platform; contest participants;

I. INTRODUCTION

Online crowdsourcing contests are nowadays considered an alternative way for firms to innovate [1], [2]. In an ideation contest, a firm opens a call for ideas or outsources an innovation-related problem to a population of individuals (the crowd) and provides an award to the individuals that propose the best ideas or solutions [3]. Companies, but also universities and public institutions, increasingly use online contests as a complement to in-house research and development [4]. It is the case of Dell with the Dell Social Innovation Challenge, which collected thousands of ideas with world-changing possibilities. Or Massachusetts Institute of Technology that opened the MIT Climate CoLab, to devise solutions to climate change. But also governments, to develop innovations going from urban management to daily-life services [5]. The benefits of these initiatives led to the growth of platforms such as Innocentive, that offers crowdsourcing services for its clients providing innovative solutions to a variety of problems. Although these communities of innovators are not a new phenomenon, the difference today lies in information technology. By radically changing the dynamics of interaction, advanced information technologies enable the involvement of a larger and diverse pool of individuals. Hence, from one side, extending the opportunity for innovation to a broader and more diverse audience [6]. This prompted the rise of a completely new business area, web-based intermediaries, that offer crowdsourcing services to companies [7]. On the other side, tapping such a diverse audience provides relevant benefits to firms, such as the collection of ideas that score significantly higher in terms of novelty and benefits provided than ideas internally conceived [8], [9]. Higher degrees of openness (i.e. high access to external knowledge) are positively associated with improved new product and service development performance, in terms of better knowledge, development of internal competencies and improved innovation outcomes (Füller, Hutter, & Faullant, 2011). This open method can bring much higher problem-solving rate [11] and creative ideas and contributions from users (Füller et al., 2011). Each single contribution, indeed, when aggregated provides better solutions than single experts do [12], as the "collective intelligence" might mitigate the effects of human biases [13]. Further, in most cases, the membership to the so-called "crowd" does not require specific skills or capabilities. This lack of specificity plays a valuable role in the process of new product development when individuals who try to resolve problems outside their area of expertise have usually better outcomes [11], [14].

However, the observed existence of an N-effect, a relevant negative effect of an increased number of participants in a contest [15] suggests that crowdsourcing contests should be carefully designed in order to provide valuable results and paybacks. A shift of outcomes, due to a lack of motivation has, indeed, been observed in correspondence of a higher number of participants in crowdsourcing contests and evidence of better contest outcomes is associated to the number of contestants' reduction [16]–[19]. If we consider the two effects together, it is easily observable that a greater number of competitors creates a trade-off in performance, generating the phenomenon known as parallel effects [20]. The immediate consequence of such evidence lies in the need for companies to properly design and manage their crowdsourcing activities to properly engage the crowd.

Previous studies investigated the crowd characteristics and how companies should deal with them [21]. Researches matched the characteristics of the crowd with key organizational needs [22], [23], analyzed the processes used to source and aggregate contributions from the crowd [6], [24] or concentrated on the best approach a company can adopt to tap a crowd [25]. Other studies concentrated on which individual personality traits affect quality output [26], [27] and the impact on crowdsourcing effectiveness, best practices, challenges and implications [28]. Prior studies [20], [29] analyzed the optimal number of contestants in ranked based innovation contests or in dynamic contests,

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expertise-based and with clear requirement specifications. However, the desirable number of contestants in online ideation contests, where the individuals are invited to provide ideas or solutions to innovative issues with no clear requirements, is still an unexplored issue. Ideation projects are, indeed, different from other typologies of contests [30] in terms of complexity and creativity required by the task [31]. For these contests, the performance (scores, knowledge) of participants does not represent an appropriate measure of outcomes: contestants work together adding single contributions to an overall project, thus the individual outcome cannot be judged aside [32]. In such contests, other measures of performance need to be assessed, typically related to the final offer (the product or service developed) and not to the individual skills or expertise. The aim of this work is to explore this issue, providing an answer to the question "Free entry or a restricted number of participants yields better outcomes in online ideation contests?".

We contribute to extant research on the field by analyzing the effect of an increasing number of participants on three crowdsourcing ideation contest performances: (i) market performance, in terms of sales (ii) innovation performance, in terms of patents generated and (iii) process performance, in terms of time to market of the innovation. From a managerial point of view, these are extremely relevant aspects when deciding the configuration of an online ideation contest. Thus, they may help both intermediaries in designing effective online contests and companies in selecting crowdsourcing services that better suit their needs.

II. Theory and Hypotheses Development

A. Effect of participant numerousness on innovation performance

N-effect has been defined as a relevant negative effect on the performance of an increased number of competitors, due to reduced motivation [15]. A shift of outcome can be provoked by a lack of motivation due to diluted winning probabilities when the number of participants increase [16]–[19]. In such circumstances, reducing the number of contestants can yield a better outcome. When the award of the contest is directed to a sole contestant (the winner-takes-all mechanism), a sole participant will not be incentivized in doing his best because of a lack of other competitors against being assessed. In such circumstance, adding a minimum level of competition would increase the participant effort [16], [33]. Increasing the number of competitors, however, dilutes participants' effort due to decreasing chances to win [15], [34] leading to a downward shift in outcome distribution. Prior research in expert-based contests, found that this effect is stronger among the higher percentile of performance distribution [20]. In ideation contests, participants' performances are manifest only at the end of the contest, when the seeker and the community judge the ideas proposed. In other words, participants do not know the quality of submitted ideas before the end of the contest. Consequently, an increasing number of participants may not depress high-performance individuals in ideation contests.

Further, a greater number of contestants increases the likelihood that at least one competitor will find an extreme-value solution [25] and may lead to a more diverse set of solutions [30]. This is particularly true in ideation contests where technical expertise is not a relevant factor and participants may have different backgrounds and skills: high uncertainty tasks, such as new product and service development, are more likely to be solved when the diversity of the contributors is fully exploited [35] and there is greater technical distance between the product domain and the contestants'own field of expertise [36]. Putting together the two effects, we expect that, in ideation contests, increasing participants will not depress high-performance individuals but conversely results in higher probability of extreme-value solutions, thus improving contest innovation performance. More formally:

H1: There is a positive association between the number of participants and innovation performance in ideation contests.

B. Effect of participant numerousness on process and market performance

A large number of contributors is desirable to complete elementary tasks in a timely manner [37] when the task object is a routine. However, when openness increases, projects usually become slower and at a higher cost [38]: in distributed decision making, indeed, a larger number of individuals contributing to a single decision increases the decision process interval. Hence, the use of the crowd itself may result in an increased time to market and, if mechanisms are not designed in an appropriate way, projects can face a high risk of failure [13], [27], [39]. When the number of individuals participating in decisions increases, motivations and consequently performance may lower. A greater likelihood of misbehavior is expected as well, leading to a loss of control by the organization [13]. We expect this negative effect will intensify in ideation contest, due to (i) the multifaceted and complex nature of product development tasks, requiring coordination and cooperation among different actors (ii) the nature of ideation contests, requiring the conjoint work of hundreds of individuals. Thus, an increase in participants may likely associate with reduced process performances, in terms of time to market.

Product market success may be negatively affected by increasing lead time [40], [41]. This is even more important if new product development represents a core capability of a firm [42], as for crowdsourcing platforms. Successful companies, in various industries, tend to launch new products more quickly than less successful competitors, to respond more effectively to changes in technologies and customer tastes, as well as to tap different customer segments (Sanchez, 1995; Womack, Jones, & Roos, 1990). Based on this discussion, we assume that an increasing number of participants in ideation contests will lead to a greater time to market and to reduced market performances, in terms of sales. More formally:

H2: There is a negative association between the number of participants and process performance in ideation contests.

H3: There is a negative association between the number of participants and market performance in ideation contests.

III. Data and Methods

A. Data collection

We collected data on the online ideation contests ran on a US-based crowdsourcing platform. Ideas are gathered via the platform website and mobile app and can be submitted by any individual. Once submitted, the platform community, composed by both the crowd and the internal staff, judges the

ideas and decides if they are good enough for further development. The crowd may be composed of hundreds or even thousands of influencers that do not only vote for the ideas but also help in each stage of the development process. If the final product comes to be satisfactory, the platform commercializes it.

In our study, we gathered data about all the product innovations sold by the crowdsourcing platform at a specific point in time. Each product represents the output of an ideation contest ran on the platform. For each product, the following information was available: price, total units sold, number of influencers, product category, time in store and length of development time in months. We matched these data with patent data from USPTO (United States Patent and Trademark Office). The platform owned 15 patents, each of them protects from one to nine inventions. All the information we gathered were publicly available. Eventually, we have a cross section dataset of 106 observations at the ideation contest (product) level. Table 1 shows the descriptive statistics.

Every single product was developed by on average 1700 individuals, the range goes from 108 to almost 6000. The development time ranges from one month to two years, with an average development time of 5 months. One out of three products the platform sells are patent pending or covered by patents. On average, each product has sold 33,540 units, with a considerable dispersion. In fact, the range goes from 65 to 621,261 units sold. The products sold are very heterogeneous as the price range goes from $ 1.99 to over $ 200.

B. Variables

For what concerns the innovation performance, we use a dummy variable for whether the platform filed a patent application for the invention. The dependent variable for process performance is the time to market, i.e., the number of months spent from the time the product entered the platform until it was released for sale. Finally, for testing market performance, we estimate a demand function, and we use the cumulative number of units sold on the platform. Our explanatory variable is the (log of the) number of contributors to the product. As control variables common for all our models, we use a set of product category dummies to isolate category-specific trends and a trend variable for the year of launch to control for the different technological vintage. For the estimation of the innovation performance, we include the development time, as products that were developed for longer may be intrinsically more likely to be patented. For the estimation of the market performance, we include the price of the product -as we are estimating a demand function- together with the development time and a dummy variable for patenting because patented inventions can be more successful than non-patented ones as they may have better quality.

C. Study Design

In order to estimate our hypotheses, we will use two different specifications. First, we use a log-linear OLS regression, where we take the logarithm of our dependent variable because it is non-negative. Second, for a more precise estimation, we use either Poisson or negative binomial regression, and logit for innovation performance. The regression equation (1) is the following:

$$Y_i = f(\gamma I_i, BX_i, \lambda_i) \quad (1)$$

where Y is the dependent variable of interest (respectively time to market, units sold, and patent), I is the number of influencers on the project, X is a set of product-specific control variables, and λ is a dummy variable for product's category.

IV. Results

Table 2 shows the results of our hypotheses. The first three columns deal with innovation performance. Here the dependent variable is a dummy variable for the patented product. In the univariate model, model 1a, an increase of 1% in the number of influencers is associated to a 7.3% increase of the probability of patenting the invention. In model 1b, once controlling for year of launch, time to market, and product category, the association gets even stronger, 13.3%. The significance of the result does not change once we use a logit model – model 1c. To conclude, there is a positive association between the number of contributors and the probability of having an innovative outcome, supporting hypothesis 1.

Model 2 tests the hypothesis about process performance. Model 2a is a simple univariate regression, model 2b adds controls for category and year of launch, and model 2c is the same regression of model 2b but is ran using maximum likelihood models for count variables to account for a more precise distribution. For what concerns process performance, we can see that the coefficient for the number of contributors is positive and significant after controlling and using a different specification. A 1% increase in the number of influencers correlates with between a 39% and a 43% increase in the time the product requires to hit the market. Products with more contributors are associated with negative process performance as these products take a longer time to reach the commercialization phase. This lends support to hypothesis 2.

In model 3, we test the associations between the number of influencers and the number of units sold. The coefficients of the univariate (model 3a) and multivariate (model 3b) models are negative and significant. A 1% increase in the number of contributors is associated on average to a decrease in the number of units sold from 85% to 98%. Given the limitations of the data and the model, the quantities need to be interpreted with caution. However, the significance of the model remains also using negative binomial regression (model 3c). Overall, results support our hypothesis 3: larger number of contributors is associated with more negative market performance.

V. Discussion, conclusions and implications

The purpose of our research was to deepen the understanding of the relation between crowd size and ideation contest outcomes in terms of market, innovation and process performance. Through a cross-sectional analysis, we found support for the assumption that a greater number of participants in an ideation contest, where the crowd participates at the development of new products or services, associates to a decreased market performance, in term of sales and decreased process performance, in terms of time to market. Conversely, we found that a greater number of participants is associated with higher innovation performance, in terms of patents. Thus, we contribute to academic research by depicting the participation mechanisms in play in ideation contests, deepening extant knowledge on the impact of crowd participation design on contest

performance. Further, we enriched existing research on ideation contests, a specific typology of crowdsourcing contests, where peculiar indicators of performances need to be defined.

TABLE I. DESCRIPTIVE STATISTICS

	Variable	N	Mean	Std. Dev.	Min	Max	(1)	(2)	(3)	(4)	(5)
(1)	***Number of Influencers***	106	1719	1215.71	108	5783	1.000				
(2)	***Time to Market***	95	5.2	9	1	48	0.246	1.000			
(3)	***Patented***	106	0.34	.48	0	1	0.197	0.188	1.000		
(4)	***Units Sold***	106	33.54	107.54	65	621.26	-0.204	-0.151	0.101	1.000	
(5)	***Unit Price***	106	24.13	32.78	1.99	279	0.164	0.027	-0.036	-0.082	1.000

TABLE II. HYPOTHESES TESTING

	(1a) Patented (=1)	(1b) Patented (=1)	(1c) Patented (=1)	(2a) Log (Time to Market)	(2b) Log (Time to Market)	(2c) Time to Market	(3a) Log (Units sold)	(3b) Log (Units sold)	(3c) Units Sold
Model[a]	***OLS***	***OLS***	***Logit***	***OLS***	***OLS***	***Poisson***	***OLS***	***OLS***	***NegBin***
Log(Influencers)	0.073** (0.009)	0.133** (0.026)	0.697*** (0.114)	0.431*** (0.092)	0.393*** (0.108)	0.632*** (0.145)	-0.859*** (0.240)	-0.989*** (0.232)	-1.483*** (0.296)
Price							-0.011+ (0.006)	-0.008 (0.006)	-0.009** (0.003)
Year of launch		0.000 (0.000)	0.000 (0.000)		-0.001* (0.000)	-0.001*** (0.000)		-0.000 (0.000)	0.000 (0.000)
Time to Market		0.007 (0.005)	0.023 (0.023)					-0.030 (0.020)	-0.054*** (0.011)
Patented(=1)								0.674 (0.535)	1.683*** (0.420)
Constant	-0.178 (0.103)	-0.715* (0.189)	-6.188*** (0.938)	-1.667* (0.639)	-0.061 (0.986)	-1.423 (1.143)	14.48*** (1.758)	16.21*** (1.624)	20.22*** (2.003)
Category FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Log(alpha)						-0.257 (0.173)			0.725*** (0.0993)
(Pseudo-)R^2	0.018	0.156	0.114	0.163	0.294	0.075	0.173	0.273	0.035
N	106	95	94	95	95	95	106	95	95

[a]Robust standard errors in parentheses. + p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

This study raises a number of managerial implications. The observed existence of a trade-off in participants' numerousness in ideation contests suggests that despite the enthusiasm and attention paid by both scientific and practitioner literature, crowdsourcing should be carefully designed and remarkably not "over-inflated" in order to provide valuable results and paybacks. The immediate consequence of such indication lies in the need for crowdsourcing intermediaries to properly design ideation contests and to define the desired openness according to the company objectives. The evidence presented in this work suggests that different objectives related to crowdsourcing may represent the key for a proper design and an improvement of crowdsourcing services. Indeed, referring to the largely analyzed exploration-exploitation dichotomy [46], [47], it seems that inclusive ideation contests may be more consistent with exploration, where time constraints could be less pressing and where there is the ability to consider as many options as possible. In other words, when companies' objective is to produce innovation, high participation ideation contests show to be a desirable solution. Either the company or the platform managing the crowdsourcing initiative will need to structure the contest in an open form and potentially, advertise the initiative and provide relevant incentives and support to participation. Conversely, when exploitation is in play, i.e. innovation requires to be turned into specific products, with tighter budgetary and time constraints, a more selective approach to crowdsourcing may be more beneficial. In such cases, closed and selective contest participation will yield better market and process outcomes. In conclusion, we call for a proper crowd participation design, related to the different objectives

crowdsourcing activities may represent, in an exploration-exploitation perspective.

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