A Stock Market approach to Online Distributed Innovation : The trade-off between speculation and innovation performance

J. Andrei Villarroel
CLSBE & MIT Sloan School of Management
5 Cambridge Center NE25-792
Cambridge MA 02142, USA

andreiv@mit.edu

Filipa Reis
CLSBE
Palma de Cima
1649-023 Lisbon, Portugal

filipa.reis@ucp.pt

ABSTRACT

The research in this study looks at the effectiveness of an online stock market for innovation (SMI) implemented inside a large multinational firm. Alike financial stock markets, the SMI is prone to speculation. We describe this initiative and study the association between participants' speculative behavior and their innovation performance by looking at the actual transactional history of their participation in the market (N=6,067 participants). Moreover, we supplement our analysis with individual level data derived from a survey of a sample of the employee population participating in the initiative (N=403 respondents). On the one hand, our findings indicate that some speculation activities are positively associated with better innovation performance. On the other hand, controlling for strict speculative behavior, we find that it significantly and negatively impacts innovative performance. This evidence suggests that while contributors speculating in the SMI innovate by doing so, strict speculative behavior could be potentially detrimental. The speculative nature of this crowdsourcing innovation initiative provides novel insights about this alternate approach to internal knowledge markets. Our findings contribute to the innovation management literature by shedding light on a stock market model of distributed innovation allowing the firm to leverage upon its existing workforce to expand its ability to innovate.

Keywords

crowdsourcing, distributed innovation, platform strategy, stock market for innovation, firm boundaries, virtual organization.

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Categories and Subject Descriptors

K.4.3 [**Computers and Society**]: Organizational Impacts – *computer-supported collaborative work reengineering.*

General Terms

Management, Measurement, Performance, Human Factors, Theory.

1. INTRODUCTION

Hayek [14] reasoned that the economic problem was not simply an issue of resource allocation but rather a matter of effective utilization of the knowledge spread throughout society. In this sense, economies face the challenge of finding effective ways to access, evaluate, and use the knowledge held by its members in order to attain development goals. One way modern economies have managed to advance towards this goal is through competitive capital markets, where active trading of investment positions in competing sources of value, collectively helps identify their relative value.

At the level of a large corporation, Hayek's arguments can be extrapolated to suggest that knowledge inside large multi-business firms may be just as widespread. Therefore the problem of knowledge utilization such firms face may be similar in nature. The question arises of how to effectively leverage upon the many valuable pieces of information scattered across thousands of employees inside a large multi-business firm. Stock markets for innovation are being used as such a mechanism. This paper offers insights about the effectiveness of one such model of distributed innovation.

Early on, different models of online distributed innovation —external to the firm— were identified as successful examples of how firms could tap from the knowledge dispersed across society beyond the firms' boundaries —also commonly referred to as "crowdsourcing" initiatives [15]—, such as: Innocentive [17] (competitive), the Netflix Prize [30] (pseudo-competitive), TopCoder

[10; 6] (competitive vs. collaborative), among others. In sum, the emergent literature on "crowdsourcing" has been mostly focused on innovation initiatives external to the firm. What large multi-business firms are doing regarding crowdsourcing inside the corporate walls is little researched.

Recent literature on the topic of firm internal online distributed innovation has been mostly qualitative [3], or experimental [27]. Our study offers quantitative insights about this intra-corporate crowdsourcing phenomenon [32] in a real-world implementation. We analyzed a distributed innovation initiative inside a large multi-business firm in the form of a Stock Market for Innovation (SMI). Section 2 provides the theoretical background surrounding our research. Section 3 provides the description of the Stock Market for Innovation. Section 4 presents the method and data used in our analysis. Section 5 discusses the results of this paper. Section 6 offers the conclusions of our work.

2. THEORY AND HYPOTHESES

From a broad perspective, three theoretical lenses offer a context to describe the nature of the phenomenon addressed in this paper. Firstly, private-collective organization theory, where cross-boundary organizational processes take center stage [34]. These processes are based on the free revealing of proprietary information (individually-held knowledge in this case), contributing to the development of knowledge commons (held by the corporation as a whole in this case). Secondly, distributed innovation theory, which acknowledges the "distributed intelligence" found in online "communities of practice" [20]. Online communities have been shown to be an increasingly important source of innovation beyond the formal boundaries of the firm [18; 17] (business units, hierarchical roles, geographic locations in this case, as exemplified by [32]). Thirdly, human computation theory and collective intelligence, in which humans act as an extension to networked computers, solving problems together that are otherwise computationally intractable [24; 25]. Individuals take part in distributed algorithms to effectively enact innovation by engaging in online distributed games [10; 33; 16] (a virtual stock market for innovation in this case). These three lenses contribute to explain the socio-technical phenomenon commonly referred to as 'crowdsourcing', of which the SMI is a particular instance.

More specifically, the theory in this paper deals with the fact that firms often lack communication channels [7] and formal selection processes [2] for exploiting employees' ideas. Online knowledge markets [3] —for prediction, preferences, ideas, or innovation— enable an interactive process for sourcing, filtering, and evaluating ideas [28] from different and disperse sources within the organization, efficiently aggregating the unevenly distributed information held by individuals through the price mechanism [14]. In this context, the SMI —subject of our study— is essentially an online platform implementing a distributed task-oriented process to aggregate and assess the value of competing pieces of knowledge held by the members of the associated online community of employees gathered around it [30], via a stock market mechanism.

However, knowledge markets are not safe from deviating behaviors and biases such as fraud [4], market manipulation [8; 12; 11], and ownership effects [27; 21]. In the specific case of the SMI, participants' expectations of realizing capital gains creates an incentive for *speculation* [29] as **defined** by Kaldor [19, p.1] :

"the purchase (or sale) of goods with a view to re-sale (re-purchase) at a later date where the motive behind such action is the expectation of a change in the relevant prices".

On the one hand, as per this definition, the main criticisms of speculation consist of it being a non-productive activity that significantly affects relevant market prices and increases market's volatility [1]. More often than not, traders need to spend substantial time and resources in speculation, leading private returns to outweigh the benefits to the community or society [23; 5].

On the other hand, however, the right to sell the acquired assets increases participants' willingness to pay for those assets relative to what they would be willing to pay if there was no such possibility [13]. Hence, people should naturally want to invest on idea stocks, thereby assigning 'increasing value' to the better innovations set forth in the marketplace.

Therefore, placing a direct bet on one idea should formalize the positive belief that an individual has on the value of that one idea relative to other investment choices available. Mimicking behavior and reciprocity [9] (i.e. "Do unto others as you would have them do unto you") would lead to expect that the successful innovator be committed to long-term bets on ideas.

H1A: Buying behavior (in the Idea Trading Market) is positively associated with individual innovation performance.

Removing a bet from an idea removes the commitment an individual has on an idea that he or she had previously placed a bet upon. The more an individual sells its positions on previously supported ideas, the less committed he or she is to the success of any one idea.

H1B: Selling behavior (in the Idea Trading Market) is negatively associated with individual innovation performance.

Prizes are expected to motivate participation, which would, in turn, contribute towards the desired goal of innovation. However, the auction reward mechanism may encourage participants in the SMI to speculate, bidding for prizes instead of innovating or investing on innovative ideas.

H2: Bidding behavior (in the Reward Auction Market) is negatively associated with individual innovation performance.

3. STOCK MARKET FOR INNOVATION

The Stock Market for Innovation (SMI) is an online platform that replicates some features of a financial stock market. On the SMI, company employees can speculate on ideas posted by peers. An idea is akin to equity or stock owned by an individual contributor, upon which others can choose to invest using a virtual currency.

There are two aspects of the SMI: the Idea Trading Market (ITM) where ideas are traded, and the Reward Auction Market (RAM) where prizes are auctioned.

In the ITM, Investors "buy" into an idea by placing an investment on it. They "sell" out of an idea and instantly recover the then current market value of the stock. Finally, they "bid" for rewards in the RAM, using the proceeds of their participation in the SMI.

Participation in the SMI is anonymous. Each participant is given the same initial amount of credits. There is a time limit for each idea to be traded in the market. When the trading time for the idea expires, it leaves the market with a value representing the market's belief in it. At this time investors realize the gains or losses of their investment.

The process through which an idea evolves comprises:

(1) An idea is first 'submitted' to the SMI and goes through a process of validation to ensure originality and clarity;

(2) A 'validated' idea is then actively traded in the SMI. After the trading period expires, an idea with a belief value higher than a specified threshold is approved.

(3) An idea 'approved' by the market becomes candidate for implementation.

Figure 1 shows the empirical valuations of ideas upon their exiting the SMI over time.

4. METHOD AND DATA

The research for this paper was conducted in collaboration a major information and communications services company operating in Europe. In this paper we present two sets of results, Study I and Study II, which build on each other for the purposes of enhancing the validity of our findings. Together, they provide insights on the effects of individual speculative behavior — measured by each individual's transactions on the SMI— on innovation performance —measured by the performance of each individual's idea portfolio. In particular, Study I explores the direct relationship of these variables for all 6,067 participants in the SMI initiative. Study II explores the same relationship, but it does so for a sample of 403 survey respondents for whom we know detailed information about their demographics and motivations. The regressions presented in our analysis are structured in the same way for both Study I and II.

4.1 Data and Variables

Two sources of data were used for analysis: (1) historical market transaction data on employee participation in the SMI over an eight-month period, and (2) survey data of a sample of registered SMI participants, exactly eight months into the initiative. The transactional data we have covers all 6,067 SMI participants at the time of our study. Of these, 3,055 (50.35%) were active participants, namely employees who had either submitted, invested, or commented on an idea. The survey data we have covers 403 participants of the SMI who responded to a survey we administered to a sample of 2,810 employees. The respondent population, had an average age of approximately 36 years, and consisted in 140 females (35%) and 263 males (65%). 81% of respondents had a university degree or a higher degree of education. These data are consistent with the employee population demographics at the company.

Dependent variable

Innovation Performance. As stated in section 3, ideas go through a 3-stage process as they progress in the SMI. We attributed weights to each stage, commensurate with the proportion of ideas that get past each stage. Our dataset comprises 2719 ideas submitted, 1,694 ideas validated, and 332 ideas approved. This is, there are 1.6 times more ideas submitted than validated, and 5.1 times more ideas validated than approved.

$$\begin{aligned} \text{performance} = {} & \text{ideas\_submitted} \\ & + 1.6\ \text{ideas\_validated} \\ & + 5.1\ \text{ideas\_approved} \end{aligned} \qquad (1.1)$$

The performance variable has a negative binomial distribution, which corresponds to the type of regression used in the statistical analysis.

Independent variables

A dummy variable 'speculate' defines strict speculative behavior in the SMI based on the following condition: never having had an idea validated for trading, and having either sold or bid on the platform.

$$\text{speculate} = (\text{ideas\_validated} = 0) \text{ AND } (\text{bid}>0 \text{ OR } \text{sell}>0) \quad (1.2)$$

The remaining independent variables: buy, sell, and bid, are transactional data from the SMI, described in Table 1.1 (Study I) and Table 2.1 (Study II).

Control variables

Demographic controls for individual employees are age, gender, education, and tenure with the initiative.

4.2 Method

For each stage of our analysis, namely Study I and Study II, we ran four statistical regression models with individual innovation performance as the dependent variable. Model 1 explores the association of strict speculation with performance, using all the actual transactional data from the initiative. Models 2-4 build upon Model 1 by introducing buy, sell, and bid, one at a time to analyze the incremental effect of these factors associated to speculative behavior on performance. Study I looks at the link between speculative behavior observed in the transactional data for the SMI for *all* registered participants. Study II introduces demographic controls for a sample of the SMI registered participants who answered a survey we conducted inside the firm.

5. RESULTS

Study I

Our statistical analysis exploring the association between speculative behavior in the SMI and innovation performance for *all* registered participants is presented in Table 1.2.

Results from Model 1 show that strict speculative behavior has a negative and statistically significant ($p<0.01$) association with innovation performance. Models 2 to 4 show that this association remains strong as concurrent explanatory variables are introduced. Model 2, introduces buy, which presents a positive and statistically significant ($p<0.01$) relationship with innovation performance that continues in the ensuing models. In Model 3, sell is introduced, presenting a negative and statistically significant association ($p<0.01$) with performance also maintained in the following models. In Model 4, bids are introduced, presenting a positive ($p<0.01$) relationship with innovation performance.

Therefore, we find strong support for hypothesis H1A and H1B, while categorically rejecting H2. This means that, controlling for strict speculators, speculative behavior on the part of other SMI participants is actually positively associated with higher individual innovation performance.

Study II

Our statistical analysis exploring the association between speculative behavior in the SMI and innovation performance for the sample of *survey respondents* is presented in Table 2.2.

Results from Model 1 show that strict speculative behavior has a negative and statistically significant ($p<0.01$) association with innovation performance. Models 2 to 4 show that this association remains strong as concurrent explanatory variables are introduced. Model 2, introduces buy, which presents a positive and statistically significant ($p<0.05$) relationship with innovation performance that continues throughout models 2, and 3, loosing all significance in Model 4 when bids are added to the regression model. In Model 3, sell is introduced, presenting a negative and statistically significant association ($p<0.05$) with performance which gains significance in Model 4 ($p<0.01$). In Model 4, bids are introduced, presenting a strong positive ($p<0.01$) relationship with innovation performance.

Hence, we find support for hypothesis H1B, while rejecting categorically H2. Finally, we find no strong support for H1A. This means that controlling for strict speculators, some speculative behavior on the part of SMI participants is actually positively associated with higher individual innovation performance.

Looking at the impact of the control variables, we observe that tenure on the SMI has a positive and significant ($p<0.01$) impact on performance across all models. This means that employees who have been participating for a long time have (on average) a stronger portfolio of ideas than the more recent participants. The gender control (female) shows a negative and weakly statistically significant ($p<0.1$) association with performance in Models 2 and 3; not showing statistically significant results in the remaining models. This may imply that female participants may underperform (albeit not so clearly) their male counterparts in the SMI initiative. This finding —albeit in an intra-corporate context— offers a contrasting result to that of Jeppesen and Lakhani in the context of crowdsourcing scientific problem solving [17]. The variables age and education did not present any statistically significant results.

6. CONCLUSIONS

In this paper we developed a study of the effectiveness of an intra-corporate crowdsourcing initiative for innovation [32], referred to as the Stock Market for Innovation (SMI). Internal resistance within traditional organizations is a frequent reaction to "distributed innovation systems" [22]. Insiders cling to their "monopoly on relevant knowledge" [22] holding back the potential of these types of initiatives to contribute to the growth and development of the organization. The corporate-wide SMI initiative, subject of this study, seems to overcome this challenge for the benefit of the organization.

The SMI adopts a three-stage funneled model for innovation, using an anonymous stock market as the key aspect for both enhancing and evaluating competing ideas, using the price mechanism as the means to define the success of an idea. However, the speculative nature of such a model of online distributed innovation suggests that it could be prone to speculative behavior. Participants may speculate against contributing to the long-term goal of effectively valuating competing ideas, in exchange for the immediate rewards that result from cashing out of the Idea Trading Market, and bidding for rewards on the Reward Auction Market (cf. Section 3).

The results of two studies, Study I, analyzing the transactional data of *all* 6,067 participants in the SMI, and Study II matching 403 survey responses with their corresponding transactional data, consistently show that: (1) speculative behavior —more specifically, buying and bidding— is positively associated with better innovation performance, although (2) selling behavior —also associated with speculative behavior— is negatively associated with innovation performance, and (3) strict speculative behavior —defined as focusing exclusively on trading and bidding activities— is negatively associated with innovation performance.

This evidence suggests that while contributors speculating in the SMI innovate by doing so, strict speculative behavior may be potentially obstructive. Furthermore, qualitative evidence gathered through the open comments left by our survey participants further reinforced the statistical findings:

"(...) the stock market "players" bet to gain virtual currency hurting the good ideas".

—anonymized contributor 1

"The SMI can be seen as an easy way of gaining prizes, instead of a true innovation program; it is easy to accumulate virtual currency, sacrificing for that purpose ideas that would eventually be interesting."

—anonymized contributor 2

These findings contribute to the innovation management literature by shedding light on a stock market model of distributed innovation allowing the multi-business firm to leverage upon its entire workforce to increase its ability to innovate.

A recent stream of research on motivation in external firm-sponsored crowdsourcing initiatives has found that factors such as fun, free time, challenge [22; 26; 31] are associated with higher innovation performance. Future research should explore the link between innovation performance and employee motivational factors —such as values towards the organization— and features of the platform —such as social interaction tools. Such research should contribute towards making online distributed innovation platforms more effective in large organizations.

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Table 1.1 Descriptive statistics of all variables of interest (Study I)

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
performance	[individual innovation performance]	6067	1.17	5.92	0	226
speculate	[ideas validated = 0 AND (bids > 0 OR sell > 0)]	6067	0.08	0.28	0	1
buy	[number of "buying" transactions made in the ITM]	6067	6.55	53.97	0	2776
sell	[number of "selling" transactions made in the ITM]	6067	3.12	33.17	0	1681
bid	[number of "bidding" transactions made in the RAM]	6067	0.11	0.99	0	25

Table 1.2 Regression analysis for all participants using innovation performance as the dependent variable (Study I)

	Model 1	Model 2	Model 3	Model 4
speculate	**-1.924*** **	**-2.063*** **	**-2.095*** **	**-1.981*** **
	(0.148)	(0.175)	(0.178)	(0.178)
buy		**0.040*** **	**0.039*** **	**0.032*** **
		(0.006)	(0.005)	(0.005)
sell			**-0.085*** **	**-0.081*** **
			(0.014)	(0.014)
bid				**0.251*** **
				(0.055)
_cons	0.235***	-0.389***	-0.606***	-0.594***
	(0.065)	(0.056)	(0.054)	(0.054)
/lnalpha	2.607***	2.363***	2.324***	2.312***
	(0.044)	(0.041)	(0.042)	(0.040)
N	6,067	6,067	6,067	6,067

note: *** p<0.01, ** p<0.05, * p<0.1

Negative binomial regressions with robust standard errors in parentheses

Table 2.1 Descriptive statistics of all variables of interest (Study II)

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
performance	[individual innovation performance]	403	5.94	18.20	0	226
age	[years]	403	35.66	8.34	22	57
education	[highschool = 1, doctoral degree = 7]	403	3.25	1.33	1	7
tenure	for how many months have you been participating in the SMI?	403	4.88	2.91	0	12
female	[female = 1]	403	0.35	0.48	0	1
speculate	[ideas validated = 0 AND (bids > 0 OR sell > 0)]	403	0.13	0.34	0	1
buy	[number of "buying" transactions made in the ITM]	403	34.44	166.28	0	2776
sell	[number of "selling" transactions made in the ITM]	403	18.02	101.79	0	1681
bid	[number of "bidding" transactions made in the RAM]	403	0.71	2.78	0	25

Table 2.2 Regression analysis for survey respondents using innovation performance as the dependent variable (Study II)

	Model 1	Model 2	Model 3	Model 4
age	-0.011	-0.001	0.003	-0.006
	(0.017)	(0.015)	(0.014)	(0.012)
female	-0.385	**-0.388***	**-0.376***	-0.108
	(0.314)	(0.227)	(0.225)	(0.215)
education	0.072	0.088	0.109	0.124
	(0.099)	(0.096)	(0.085)	(0.078)
tenure	**0.241*****	**0.154*****	**0.141*****	**0.129*****
	(0.060)	(0.047)	(0.046)	(0.040)
speculate	**-2.558*****	**-2.438*****	**-2.329*****	**-2.249*****
	(0.360)	(0.344)	(0.328)	(0.322)
buy		**0.006****	**0.007****	0.002
		(0.003)	(0.003)	(0.003)
sell			**-0.021****	**-0.030*****
			(0.009)	(0.009)
bid				**0.252*****
				(0.048)
_cons	0.776	0.392	-0.052	0.011
	(0.938)	(0.782)	(0.688)	(0.632)
/lnalpha	1.426***	1.292***	1.272***	1.132***
	(0.104)	(0.103)	(0.099)	(0.099)
N	403	403	403	403

note: *** p<0.01, ** p<0.05, * p<0.1

Negative binomial regressions with robust standard errors in parentheses

Figure 1. Market value of ideas upon their exit from the stock market for innovation