

Intrinsic Motivation of Open Content Contributors: the Case of Wikipedia

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1 Introduction

Modern information technology has enabled many community-based innovations, in which loosely-connected contributors, dispersed across organizational and geographical boundaries, collaborate via the Internet. This community-based model of knowledge creation differs considerably from traditional firm-based production process and has stimulated curiosity of scholars from a variety of fields. Two well-known examples are open source software (OSS) projects (e.g., the Apache project) and open content production (e.g., Wikipedia). In OSS projects, hundreds and thousands of programmers collaborate on some software code base. In open content production, contributors codify some knowledge base with wiki, a piece of server software that allows them to freely create and edit Web page content.

Research to date has focused on OSS projects almost exclusively. Most studies have focused on understanding the intrinsic and extrinsic motivation of individual software developers. Intrinsic motivation is defined as interest in or enjoyment of an activity for its own sake (Lepper 1981; Ryan 1993). For OSS developers, intrinsic motivation may come from the fun in programming and learning. Extrinsic motivation refers to doing something because it leads to separable rewards (Ryan and Deci 2000). Researchers have identified a wide variety of extrinsic motivation in OSS projects, including immediate payoffs such as monetary payment and delayed benefits such as potential career advancement and personal use of the software (Lerner and Tirole 2002).

It seems difficult to conclude from existing studies for the dominance of either intrinsic or extrinsic motivation in OSS projects. For example, Hars and Ou (2002) finds the dominance of extrinsic motivation. Lakhani and Wolf (2005) suggests that the incentive to contribute mainly comes from enjoyment-based intrinsic motivation. Bessen (2005) argues that firms, rather than individuals, are playing a more important role.

This inconsistency is not surprising. OSS projects differ considerably from each other in terms of functional-

ity and complexity of the software, degree of modularity, distributed structure of coordination, licensing, and intensity of communication among project members. It is thus unlikely that a small set of OSS projects selected in each study capture a sufficient degree of such heterogeneity. In addition, most studies use surveys. Given the inherent subjectivity and social desirability in reporting and the heterogeneity in OSS projects, it is not surprising that self-reported motivations vary considerably across studies (Lerner et al. 2006). Furthermore, it is difficult to separate the effects from these two types of motivation because of potential interplay between them. Numerous studies in sociology and economics have suggested that extrinsic motivation can undermine, enhance or have no effect on intrinsic motivation (e.g., Deci 1971; Bénabou and Tirole forthcoming). It is thus unclear whether many of the OSS projects could still have been so successful without extrinsic motivation. Finally, motivation may change over time and may be influenced by other forces and these survey-based studies provide little insight into these dynamics. As a result, little is known about why members join or leave particular projects (von Hippel and Von Krogh 2003).

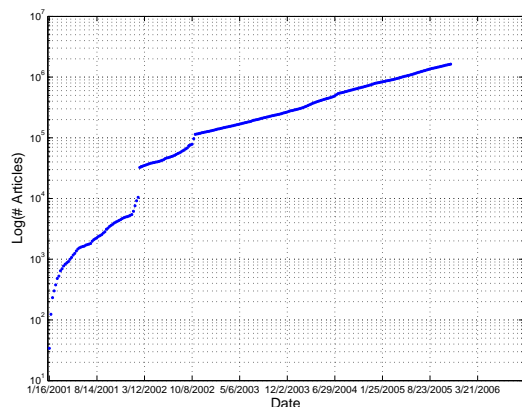
Unlike these previous studies, we conduct an initial exploration of the incentive and behavior of open content contributors in the context of Wikipedia, the largest online encyclopedia. For Wikipedians, people who write and edit articles for Wikipedia, the incentive to freely contribute largely comes from intrinsic motivation. Using theories from extant social psychology and sociology literature, we show how Wikipedia effectively enhances contributors' intrinsic motivation. To understand the dynamics of contributor incentive, we examine the relationships among social interaction, perceived competence, intrinsic motivation and performance. We hypothesize that the free contributor-to-contributor assistance (Lakhani and von Hippel 2002) in online collaboration may reduce perceived competence of content creators and as a result, decrease their intrinsic motivation. In addition, the negative impact from collaboration is mitigated by the past collaboration experience of the content creators. We find support for both hypotheses. Our results further suggest that the net effect of online collaboration on Wikipedia enhances contributors' intrinsic motivation.

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2 The Growth of Wikipedia

On January 15, 2001, Jimmy Wales and Larry Sanger put online a free encyclopedia in the form of a wiki, and named it "Wikipedia." It soon became very popular.¹ Figure 1 shows the number of Wikipedia articles on log-

Figure 1: Growth of Wikipedia Articles



Source: calculated from our data set.

arithmic scale over time. The number of articles doubles every ten weeks from the beginning to March 2002 and every 30 weeks from March 2002 to October 2002. The rate stabilizes at about doubling every 40 weeks afterwards. The growth of registered users follows a similar exponential pattern. During the first year, the number of users doubles every 10 weeks, and after that, the number doubles every 22 weeks. Today, Wikipedia is the 16th most visited site on the Web.²

3 Intrinsic Motivation and Wikipedia

Existing research on intrinsic motivation has focused on various factors that may increase or decrease it. In general, we can divide these factors into individual factors and interpersonal factors (Hackman et al. 1975; Hackman and Oldham 1980). Individual factors operate even when a person is working alone. Interpersonal factors, on the other hand, play a role only when the person is interacting with someone else.

Researchers have identified two important individual factors: a *sense of meaningfulness* and *self-determination*. A sense of meaningfulness is the perception that what one

does has purpose and is the prerequisite for intrinsic motivation to occur. The fundamental mission of Wikipedia is to give every single person on the planet free access to the sum of all human knowledge. Many participants on Wikipedia clearly fully embody this mission statement— In a recent survey of Wikipedians, they described the reason of participation with "desire to change the world for the better", "doing something great by spreading knowledge", etc.³

Self-determination is a perception that one has a choice in performing the task and is not influenced by any other source in making that determination. Studies (e.g., Zuckerman et al. 1978) find that choice and the opportunity for self-direction appear to enhance intrinsic motivation, as they afford a greater sense of autonomy. Wikipedia contributors have greater freedom than OSS developers. Anyone can edit any articles without even logging in and the updated articles are immediately available to the public.

While these individual factors often remain unchanged over time, interpersonal factors give rise to the dynamics of intrinsic motivation. Interpersonal factors consist of *perceived competence* and a *sense of relatedness* (White 1959). Perceived competence represents the extent to which a person believes that she has performed or is able to perform well at an activity (Harter 1981; Bandura 1982). The higher the perceived competence, the higher is the motivation to exert effort for the group goals. On the other hand, if a person believes that her contribution does not matter, performance motivation should decrease considerably even when this person values the meaningfulness of the task highly (Hertel et al. 2003). Results from laboratory experiments and field studies show that positive performance feedback enhances intrinsic motivation as it increases perceived competence (Deci 1971; Harackiewicz 1979), whereas negative performance feedback diminishes it (Deci and Cascio 1972). On Wikipedia, an article creator receives feedback when others edit the articles she creates. A large number of revisions of an article suggests that the original article was poorly written. As a result, this "free contributor-to-contributor assistance" sends negative feedback to the article creator. We therefore hypothesize:

H1: Editing an article decreases the article creator's incentive to contribute.

On the other hand, Wikipedia encourages users to be bold in updating articles. As stated on its Web site, "If someone wrote an inferior article, ..., don't worry that editing it might hurt their feelings. Correct it, add to it, and, if it's total nonsense, replace it. That's the nature of a Wiki..."⁴ Therefore, we expect Wikipedians with sufficient experience in online collaboration to take

¹The detailed history of Wikipedia can be found at http://en.wikipedia.org/wiki/History_of_Wikipedia.

²Source: http://www.alexa.com/data/details/traffic_details?q=&url=http://wikipedia.org, accessed on September 8, 2006.

³See http://en.wikipedia.org/wiki/User:Linuxbeak/Wikimania_2006/Wikipedian_Survey.

⁴http://en.wikipedia.org/wiki/Wikipedia:Be_bold_in Updating pages

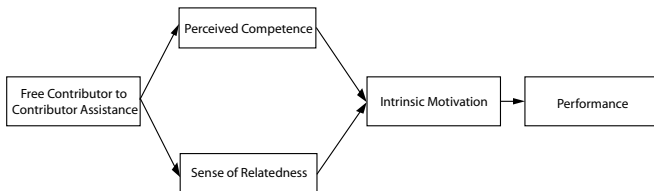
others' assistance less personally. Hence we hypothesize:

H2: The negative impact from others' assistance is moderated by the article creator's editing experience.

In addition, editing is a collaborative effort at Wikipedia. Wikipedia encourages users to discuss their revisions⁵. By facilitating collaborations among editors, Wikipedia may help establish a strong sense of relatedness among them.

We summarize the relationships between interpersonal factors and intrinsic motivation in Figure 2.

Figure 2: Relationships among free contributor to contributor assistance, interpersonal factors, intrinsic motivation and performance.

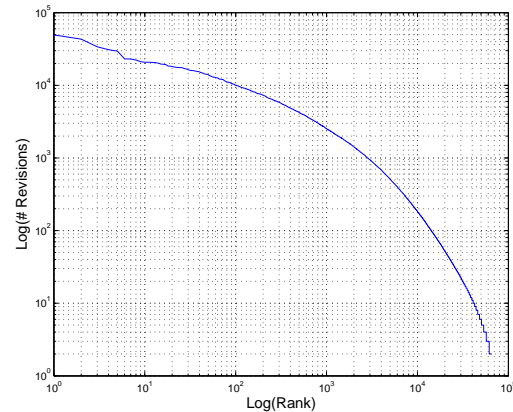


4 Data

We examine the behavior of Wikipedians directly by looking at the posting patterns of all the registered Wikipedians over time. We obtain our data set from the English Wikipedia (<http://en.wikipedia.org/>). In our analysis, we study the full text of all articles and their complete editing histories. These articles were posted and edited between January 16, 2001, and January 7, 2006. We have 1,778,594 titles in our data set. For these titles, we record the creation time, creator ID, number of words added and deleted in each revision. Governed by the power-law distribution, the revisions are highly concentrated on a small proportion of titles.

For each contributor, we record the user ID, time of first post, and a record of each contribution. Among the 326,256 contributors in our data set, 65,939 initiated at least one article. While unregistered visitors can create articles, we focus on these registered article creators in our analysis. The top five contributors each submitted more than 60,000 revisions. Figure 3 shows the log-log plot of the time-adjusted number of revisions⁶ with respect to the rank of the contributors. Interestingly, we do not observe the characteristic signature of power-law

Figure 3: Log-log Plot of Revisions by User Rank



distribution. Rather, this increasing rate of decay implies that the contribution by the more active contributors does not decrease as rapidly as it does for less active contributors.

5 Results

We now proceed to test the impact of editing on article creators' intrinsic motivation in a regression framework. Equation (1) is our regression model.

$$\begin{aligned}
 Performance_t = & \beta_0 + \beta_1 Added_{t-1} + \beta_2 Deleted_{t-1} \\
 & + \beta_3 \left(\sum_{i=0}^{t-1} TotalAddition_i \right) \cdot Added_{t-1} \\
 & + \beta_4 \left(\sum_{i=0}^{t-1} TotalDeletion_i \right) \cdot Deleted_{t-1} \\
 & + \beta_5 Age_t + \beta_6 JoiningWeek \\
 & + WeekDummies + \epsilon
 \end{aligned} \tag{1}$$

We use the performance of each Wikipedian in week t ($Performance_t$) as the dependent variable. For independent variables, we use the logarithms of the number of words added to ($Added_{t-1}$) and the number of words deleted ($Deleted_{t-1}$) from the articles the Wikipedian created in week $t - 1$.⁷ We consider addition and deletion as different forms of editing as their effects may be different. To measure the past collaboration experience of the Wikipedian, we compute the logarithms of total number of additions ($\sum_{i=0}^{t-1} TotalAddition_i$) and total number of deletions ($\sum_{i=0}^{t-1} TotalDeletion_i$) (measured by the number of words) up to week $t - 1$. We then use the two interactions, $(\sum_{i=0}^{t-1} TotalAddition_i) \cdot (Added_{t-1})$ and $(\sum_{i=0}^{t-1} TotalDeletion_i) \cdot (Deleted_{t-1})$, as additional control variables. We also add the number of weeks elapsed

⁵For example, Wikipedia promotes the so-called BRD method of revision cycles. BRD stands for "bold, revert, discuss", it encourages contributors to be *bold* in making modifications to articles, and wait for someone to *revert* the modifications, and *discuss* the case with the reverter in the "Talk" page of the article.

⁶For each user we divide the total number of revisions by the total number of weeks since the user's first contribution.

⁷We add 1 to the number before taking logarithms as some numbers can be zero.

Table 1: Regression Results

Model	(1)	(2)	(3)	(4)	(5)	(6)
$Added_{t-1}$	-0.0219 [0.0013]***	-0.0232 [0.0013]***	-0.0838 [0.0286]***	-0.1108 [0.0246]***	0.0388 [0.0006]***	0.4142 [0.0096]***
$Deleted_{t-1}$	-0.0023 [0.0013]*	-0.0042 [0.0013]***	-0.0346 [0.0250]	-0.0472 [0.0230]**	0.0192 [0.0006]***	0.1673 [0.0100]***
$(\sum_{i=0}^{t-1} TotalAddition_i) \cdot Added_{t-1}$	0.0093 [0.0002]***	0.0095 [0.0002]***	0.0714 [0.0042]***	0.076 [0.0036]***		
$(\sum_{i=0}^{t-1} TotalDeletion_i) \cdot Deleted_{t-1}$	0.0022 [0.0002]***	0.0025 [0.0002]***	0.0235 [0.0037]***	0.0274 [0.0034]***		
Age_t	-0.0019 [0.0000]***	-0.0015 [0.0000]***	-0.0246 [0.0003]***	0.0013 [8.4537]	-0.0012 [0.0000]***	-0.0212 [0.0003]***
$JoiningWeek$	-0.0004 [0.0000]***	-0.0001 [0.0000]***	-0.0046 [0.0001]***	0.0204 [8.4833]	-0.0001 [0.0000]***	-0.0047 [0.0001]***
Observations	1,946,879	1,946,879	1,946,879	1,946,879	1,946,879	1,946,879
R-squared	0.09	0.10	-	-	0.09	-
Week Dummies Included	No	Yes	No	Yes	Yes	No
Specification	OLS	OLS	NB	NB	OLS	NB

The dependent variable is the logarithm of the number of new articles created by an individual Wikipediaian in week t in the case of OLS specification, and is the number of new articles in the case of Negative Binomial (NB) specification. Heteroscedasticity-adjusted standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

since the creator joins Wikipedia (Age_t). As each contributor's knowledge is limited, we expect their contribution to decrease over time. Finally, we add the week the creator joins Wikipedia ($JoiningWeek$) to capture systematic differences in contributors joining in different periods. For instance, early contributors are able to add more articles as most articles have not been created. We also include week dummies ($WeekDummies$) in some regressions to control for possible seasonality. If our hypotheses are valid, we expect β_2 and β_3 to be negative and β_4 and β_5 to be positive.

We use the total number of new articles created in week t as the performance measure for each Wikipediaian. Our results are robust to alternative measures such as the total number of contributions (additions + deletions) in week t or the total number of words in the new articles in week t .

Table 1 summarizes the results. As our dependent variable is a count variable, we use both OLS and Negative Binomial specifications. The results from Model (1) to (4) support both hypotheses. Interestingly, adding new content to an article decreases article creator's incentive more than deleting content. This is probably because in the former case the creator may feel others are more knowledgeable and her contribution may not matter to the success of Wikipedia. In Model (5) and (6), we repeat the analysis excluding the two interaction variables. The idea is to measure the aggregate effect of contributor collaboration. The results indicate that collaboration enhances incentive to contribute overall. In addition, the coefficients of Age and $JoiningWeek$ are significantly negative in all

models except Model (4), suggesting that contribution by early participants tends to be higher and is decreasing over time.

6 Conclusion

The development of information and communication technologies has significantly enhanced our ability to share our knowledge. However, we still face two challenges. First, we need to codify our knowledge into information. As Polanyi (1967) points out, "we know more than we can say." Second, we need to be motivated to share our knowledge. Wikipedia has created an environment that facilitates communal codification of knowledge. We show, by building on theories from sociology and psychology, that on the individual contributor level, Wikipedia achieves this objective by enhancing contributors' sense of meaningfulness, self-determination, and sense of relatedness.

Consistent with earlier studies based on lab experiments and small scale field studies, we show, with our empirical study of a large online community, that the free contributor-to-contributor assistance can undermine incentive. We have also found evidence to suggest that the negative effect can be mitigated by past collaboration experience. That is, this effect tends to be more serious for new comers to the community.

Our study highlights that intrinsic motivation can play an important role in online communities. To economists

of information and knowledge management, this study offers a “behavioral” examination of individuals’ dynamic reaction to feedback.

There are a few possible directions to extend this paper, given the remarkable richness of the data set. For example, although ordinary Wikipedians do not enjoy any extrinsic rewards, the administrators, especially the founders, often derive pleasure and satisfaction from fame, possible career advancement, and even monetary compensations. A comparative study of the average users and those who became administrators may show some discontinuity in incentives, and unveil the interplays of intrinsic and extrinsic motivation. Second, historical data may help us examine how the social network of Wikipedians contributed to the development of the Wikipedia project. Theoretically, this will further our understandings of “community-based model of knowledge creation” (Lee and Cole 2003) and “communities of practice” (Wenger 1998; Wenger et al. 2002). Third, there are ample opportunities to take the behavioral perspective and examine such traditional economics questions as “provision of public goods”. Empirically, this has often been done with lab experiments (e.g., Chen and Tang 1998, and many others). A complete record of real-world interactions among Wikipedians will probably provide additional valuable insights.

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