Asia Pacific Journal of Information Systems
Vol. 30 No. 3 (September 2020), 497-512

ISSN 2288-5404 (Print) / ISSN 2288-6818 (Online)
https://doi.org/10.14329/apjis.2020.30.3.497

Anonymous Participation and Collaboration Efficiency in Online Communities

Hong Joo Lee[a], Jong Woo Kim[b,*], Hyun Jung Park[c], Sung Joo Park[d]

[a] *Professor, Department of Business Administration, Catholic University of Korea, Bucheon, Korea*
[b] *Professor, School of Business, Hanyang University, Seoul, Korea*
[c] *Research Professor, Management Research Center, Ewha Womans University, Seoul, Korea*
[d] *Professor,Information Systems, KAIST Graduate School of Management, Seoul, Korea*

ABSTRACT

Anonymity is one of the key factors that influence communication and the work behaviours of people. It is even more evident in an online community where the role of anonymity can be akin to a double-edged sword: it can increase participation while at the same time having detrimental effects due to irresponsible and disruptive behaviour. Most studies on anonymous participation in groups or communities have reported this ambivalent view of anonymity: positive or negative. Furthermore, the effects of anonymous participation may be different in a dynamic sense because the task characteristics of participation can vary across time. In this study, we hypothesise that the effects of anonymity in online collaboration differ across the stages of collaboration. We analysed 2,978 featured articles on the English-language Wikipedia website and investigated the contributions of anonymous participants. While the contributions of anonymous participants were negative to collaboration efficiency as a whole, the negative effect of anonymous participants was stronger in the earlier stage than the later stage of collaboration. These findings indicate that the effect of anonymity has two sides in terms of collaboration efficiency in the same collaborative environment.

Keywords: Anonymity, Online Communities, Online Collaboration, Efficiency of Collaboration, Wikipedia

Ⅰ. Introduction

Due to the prevalence of internet-based collaborative tools, there have been many works of collaboration by distributed users (Shao, 2009). For example, Dell and Starbucks collected product ideas from their customers (Di Gangi et al., 2010; Gallaugher and Ransbotham, 2010; Kelley and Alden, 2016) and Climate CoLab harnesses collective intelligence to address the problem of global climate change (Malone and Klein, 2007). The NASA project called "Random Hacks of Kindness (RHoK)" is developing an

*Corresponding Author. E-mail: kjw@hanyang.ac.kr

open-source technology that will address disaster management, education challenges, and crisis responses. The success of distributed collaboration and online communities relies on the number of participants because 'given enough eyeballs, all bugs are shallow' (Raymond, 1999) and a diversity of collectives eliminates individual bias. However, the lack of central authority to maintain the quality of work or coordinate tasks causes chaotic discourses or slows down the work progress.

To increase the number of participants – by lowering the barriers to participation – online communities often allow participation of anonymous users (Kane, 2011). However, the effect of anonymous participation is ambivalent: the increased number of participants may contribute positively for the overall performance, but at the same time, the arrival of anonymous contributors lacking accountability may cause additional coordination costs due to vandalism or disruptive behavior (Jessup et al., 1990; Seigenthaler, 2005; Sia et al., 2002). Consequently, there have been two opposite results of studies – positive and negative – regarding the effects of anonymity in collaboration (Faraj et al., 2011; Jessup and Tansik, 1991).

Many studies investigated the effect of anonymity in online communities on the quality of knowledge creation (Kane, 2011). Though the anonymous contribution is not trivial (Ransbotham et al., 2012), most contributions are from registered users and some elites in their communities (Ball, 2007; Wilkinson and Huberman, 2007). Thus, it is better investigating the effect of anonymity in terms of collaboration efficiency. Though minor contributions such as correcting spelling can increase the speed of perfecting knowledge, deceits in editing by anonymous users incur coordination cost to registered users for reverting the deceits. How long anonymous contributions delay the achieving of knowledge creation with certain quality?

In past studies on anonymity (Hayne et al., 2003; Kane, 2011; Marx, 1999; Scott, 2004), they identified the relationships between number of anonymous users or contributions and the performance of communities or numbers of participations as a whole without considering other aspects, such as the stages of collaborative work. Because the characteristics of tasks will differ according to the stages of collaborative work (Kane et al., 2009), the effects of anonymous participation also differ across stages. Closed- and open-group collaborations follow group developmental stages, and the characteristics of the stages differ (Faraj et al., 2011; Gersick, 1988; Kane et al., 2009; Ransbotham and Kane, 2011).

The goal of this study was to investigate how anonymity affects the efficiency of collaboration in online communities by examining the entire editing histories of 2,978 English language featured articles on Wikipedia and by studying the difference of the effects according to the stages of collaboration. Featured articles were selected as the 'best' articles by votes of the Wikipedia's editors. In this study, we controlled quality in the sense that we only focused on the featured articles. While most of the articles never reached the level of the featured article, some articles completed this level in a short period. Thus, the collaboration efficiency of editing Wikipedia articles is defined as the duration of becoming a featured article, and this study investigates the effect of anonymous participation on the collaboration efficiency. Also, there are collaboration stages that have different characteristics in online communities (Gersick, 1988; Kane et al., 2009; Tuckman and Jensen, 1977). Kane et al. (2009) suggested two stages of collaboration in online communities: the creation stage when knowledge is structured and shaped, and the retention stage, when the created knowledge gets refined

through collaboration. Studies on group problem-solving sequences also identified that the first half of the sequences is for orientation and structuring, and the other half is for maturing and finishing up the tasks (Gersick 1988; Tuckman and Jensen 1977). This study also investigates the different effects of anonymous participation on the collaboration efficiency according to the collaboration stages or sequences in online communities.

Ⅱ. Two Views of Anonymity in Online Collaboration

There have been many studies on the effects of anonymity in diverse fields, and both positive and negative effects have been reported in online collaborations (Faraj et al., 2011). Anonymity is established when there is no connection between participants' input (i.e., messages, posting) and any type of their personal information, such as nominal labels, user names, or pseudonyms (Jessup and Tansik, 1991).

Positive effects of anonymity in collaboration were reported based on diversity prediction theorem and equal participation. Collective intelligence rests some of its perceived value on the diversity prediction theorem (Scott, 2007). Crowd error is the elimination of individual noise from average individual error. Thus, crowd error tends to be smaller if it is from diverse opinions. Diversity in online collaboration generally has positive effects on task completion (Arazy et al., 2011). Anonymity gives people an equal opportunity to share ideas in a group discussion (Jessup et al., 1990; Nunamaker and Dennis, 1991; Rao and Jarvenpaa, 1991) and the tendency to work for a group goal when group members are entirely anonymous (Spears and Lea, 1992). Information can be judged only by its quality without being influenced by information providers' profession or social status (Petty and Cacioppo, 1986). Communications with anonymous partners increased communication satisfaction and task performance (Tanis and Postmes, 2007). As anonymous users are less constrained by social status, they feel more psychologically safe (Faraj et al., 2011), tend not to conform with others' opinion easily (Tsikerdekis 2013), and provide diverse opinions (Jessup et al., 1990; Marx, 1999). Although anonymous users showed a lower number of edits compared with administrators and registered users in the Wikipedia community, almost 73% of the edits performed by anonymous users are accepted by the community (Wöhner et al., 2011).

The negative effects of anonymity were mainly based on the de-individuation theory and lack of responsibility. Perceived anonymity from a crowd creates a de-individuated state, which is the loss of self-awareness, and this state leads individuals to aggressive behavior, such as anti-normative and anti-social behavior (Jessup et al., 1990; Kane, 2011; Tanis and Postmes, 2007). Because anonymous users naturally do not have a responsibility, the negative effects on group behavior are decreased concerns of responsibility (Hayne et al., 2003; Rains, 2007) and increased risks of deception (Seigenthaler, 2005). There is lower motivation for anonymous users because there are no incentives for their contributions to online communities (Anthony et al., 2009; Park and Park, 2016; Scott, 2004). In Wikipedia, it was found that the number of anonymous editors on a given article was negatively related to the quality of the article (Kane, 2011).

From an overall perspective, anonymous contributions will be less conducive to the group collaboration efficiency than the contribution of registered editors. Registered editors are more likely to care about their reputations and more value-congruent

<Table 1> Relevant Research of Anonymous Participation in Online Collaboration

Themes	Focus	Examples of research
Diversity in online collaboration has positive effects on task completion	The results of online collaboration tend to be greater if it is from diverse participants with different backgrounds	Arazy et al. (2011); Scott (2007)
Anonymity influences equal participation	Anonymity prompts (1) diverse opinions in online collaboration and (2) equal and unbiased participations	Faraj et al. (2011); Jessup et al. (1990) Marx (1999); Nunamaker and Dennis (1991) Petty and Cacioppo (1986); Rao and Jarvenpaa (1991); Tsikerdekis (2013)
Less responsibility of anonymous participants	Anonymity participants in online collaboration tend to have less responsibility and increase risks of deception	Hayne et al. (2003); Kane (2011) Rains (2007); Tanis and Postmes (2007)
No incentives for the contribution of anonymous participants	No incentives or lower motivation for the anonymous participants in online collaboration	Anthony et al. (2009); Park and Park (2016) Scott (2004)

with their community (Balazs, 1990; O'Reilly, 1989). As a result, registered editors will focus more on the validity of the contributed knowledge (Anthony et al., 2009; Park and Park, 2016), and produce more helpful knowledge, leading to a higher collaboration efficiency. Since anonymous participants have no incentives for their contribution (Park and Park, 2016) and less responsibility to complete the task (Rains, 2007), it causes deception in open collaboration and delays to complete tasks done by collaboration.

Thus, the following hypothesis is proposed in this research:

H1: The ratio of anonymous participation in a given article has negative effects on the efficiency of collaboration.

Ⅲ. Multiple Stages of Collaboration

There have been many studies on group dynamics and on phases in offline group problem solving (Bales and Strodtbeck, 1951; Gersick, 1988; Seeger, 1983; Tuckman, 1965; Tuckman and Jensen, 1977). In 'classic' studies, the innate phases of group work were described, and the stages were identified, based on observations and surveys (Bales and Strodtbeck, 1951). Although there are many distinctions, the first stage of group problem solving is an orientation for the task in general, in which group members identify the task and the way for collaboration (Bales and Strodtbeck, 1951; Tuckman, 1965). Emotional conflicts among group members emerge in the next stage due to "the discrepancy between the individual's personal orientation and that demanded by the task" (Tuckman, 1965). To alleviate such conflicts and to lead to the mature work phase, communications and open exchanges of relevant interpretations among group members are carried out (Braaten, 1974; Tuckman and Jensen, 1977). The final step is characterized as the emergence of a solution to complete the task (Lacoursiere, 1974; Tuckman and Jensen, 1977).

In contrast to these classic studies, the punctuated equilibrium model (Gersick, 1988; Gersick, 1991) explains that there is no innate phase in group problem solving, but there are sudden formations, maintenances, and revisions of work for task completion

(Gersick, 1988; Seeger, 1983). Following this view, a framework of behavioral patterns emerges in the initiation, and the group stays with the framework through the first half of its life (Gersick, 1991). Groups may show little visible progress during this time and experience transitions, based on gradual learning and discussions. Through the transition, the groups take their direction and develop until the completion of the task. Also, time-paced evolution with continuous changes were the characteristics of successful group works (Brown and Eisenhardt, 1997).

Because online communities are depicted by a fluid nature where continuous changes occur over time with a non-specific group of diverse participants (Faraj et al., 2011; Kane et al., 2009), collaboration in online communities may consist of multiple stages (Kane et al., 2009; Ransbotham and Kane, 2011). Online communities go through cycles of creation, maintenance, and recreation of knowledge (Kane et al., 2009; Ransbotham and Kane, 2011). Additionally, there are different types of challenges to resolve: ideas, structures, and style issues (Kane et al., 2009). Although chaotic perspective-taking related to solving idea-specific issues occur from the earliest stages of collaboration, it may disappear later in the collaboration; perspective-shaping related to style issues tends to occur just before an article gets promoted to a featured article. After the article gets promoted, perspective-defending related to reshaping existing knowledge usually occurs.

The early times in article creation will require more organized contributions for framing the structure of articles, while later will need parallel contributions for writing and fine-tuning articles. Thus, the following hypothesis is proposed in this research:

H2: The negative relationship between anonymous participation and the efficiency of online collaboration becomes stronger, when the article edits come earlier than the article edits done later.

Ⅳ. Research Method and Data

4.1. Data

The English language Wikipedia was established in 2001 and has produced approximately four million articles since then. Among them, fewer than 0.1% of articles are promoted to the "featured article" level. Featured articles are determined by Wikipedia's editors to be the best articles Wikipedia has to offer. In this study, we analyzed the editing histories of the 2,978 featured articles (total as of June 2012 ex-

<Table 2> Descriptive Statistics

Variables	Value	Minimum	Median	Maximum	Standard deviation
Number of featured articles	2,978				
Number of anonymous editors(Counted by unique URLs)	320,723				
Number of registered editors(Counted by unique ID)	107,673				
Number of articles initiated by an anonymous editor	696				
Average number of edits by an anonymous editor	1.976	1	1	893	4.249
Average number of articles edited by an anonymous editor	1.164	1	1	279	1.089
Average number of edits by a registered editor	17.39	1	2	24317	190.239
Average number of articles edited by a registered editor	3.384	1	1	976	13.569

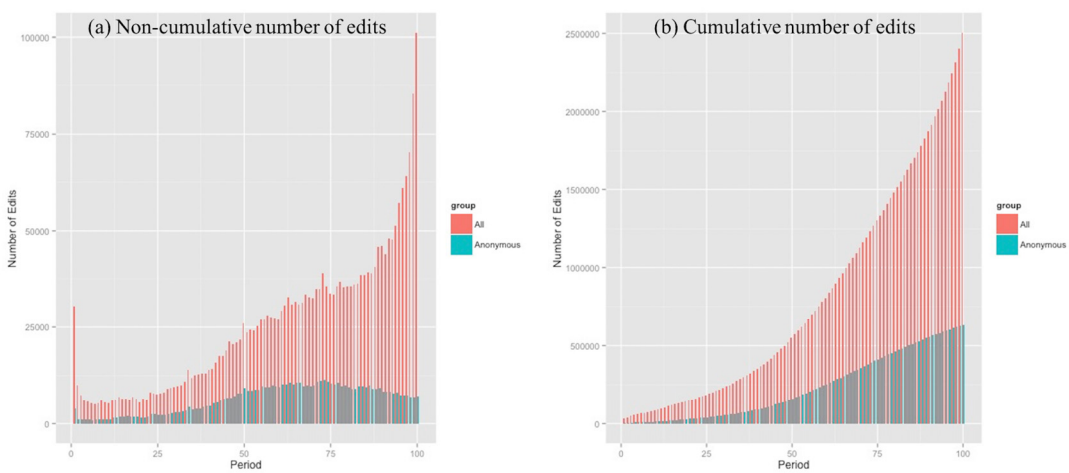
cluding those with missing promotion dates) and excluded all edits by "bots," which are automated programs, to preserve the purity of human behaviors. The descriptive statistics of the featured articles we used are summarized in <Table 2>. While IDs of registered users are listed in logs of edits in Wikipedia, anonymous participants are listed only by their IP addresses. Although registered users may not log in when they edit, we assumed edits with an IP address on the editing history were done by anonymous participants because we could not distinguish the edits done by anonymous users or by not-logged-in registered users. There are 320,723 anonymous editors in the featured articles, and they initiated 696 articles among the total of 2,978 featured articles. The average number of edits and edited articles by the anonymous editors were around 2 and 1 article, respectively.

Some anonymous participants initiated articles and participated eagerly in the early stage of articles to guide the structure of articles. Mostly, edits appeared in the later stages of article writing and corrected some minor errors, including formatting and spelling.

<Figure 1> shows the non-cumulative number of edits (a) and the cumulative number of edits (b) for all featured articles. The *x*-axis is the period and the *y*-axis is the number of edits. We divided durations of articles – from the beginning until they became featured articles – into 100 time periods to standardize all the articles. Then, the frequencies of edits were counted in these periods for all articles. Most edits by registered or anonymous users occurred in the second half of the period. While the number of edits by registered users increased as the articles move to the end period, the number of edits by anonymous users peaked in the third quarter and then decreased in the final quarter.

To investigate the contribution of editors in detail, we manually classified 1,365 anonymous edits of 30 articles and 1,401 edits of registered users for 28 articles in our dataset. Two of the authors discussed and agreed about the edit classifications. The articles were selected randomly, and the scheme to classify edits is described in <Table 3>.

<Figure 2> shows the ratios of the classifications for the anonymous and registered editors. The most common contributions were minor edits for both

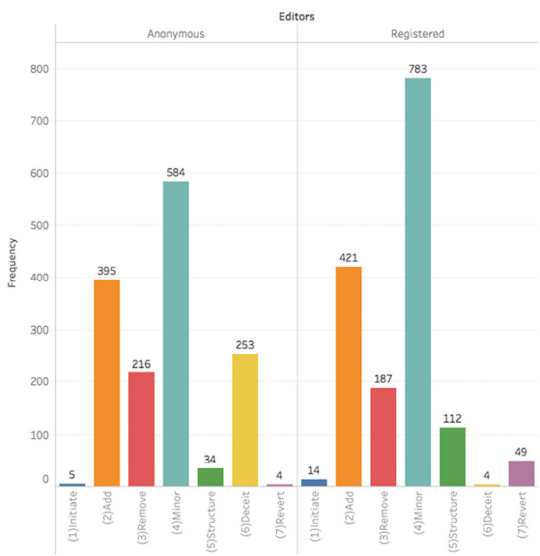


<Figure 1> Arrivals of Edits: All Articles

<Table 3> Wikipedia Classification of Edits

Classification	Descriptions
Initiate	When an editor starts a Wikipedia article.
Add	When an editor adds or supplements content, detail, external links, and references to an article. Includes article merges, addition of an article redirect link within Wikipedia, and changing of significant details on an article.
Remove	When an editor deletes substantial details, content, text, image, or links in an article.
Minor	When an editor makes corrections in punctuation, spelling, broken external links already in the article, and layout/formatting. Includes adding or correcting links, replacing words with synonyms, and adding words to a sentence that has a shallow influence on the whole article.
Structure	When an editor adds, removes, makes changes in the Categories of the article. Includes restructuring of the whole article, and paraphrasing sentences in the article without adding significant details.
Deceit/Vandalism	When an editor adds unrelated content, spam, and messages that should be in the talk section of the article. Includes deleting and changing significant content in the article.
Revert	Nullifying the recent edit or edits and restoring the article to its past form

user types (around 50% for registered and 39% for anonymous edits). While the number of structure and revert edits by the registered editors were higher, the number of vandalism events was higher for the anonymous editors. The reverts by registered editors were done mostly to correct vandalism done by anonymous users.



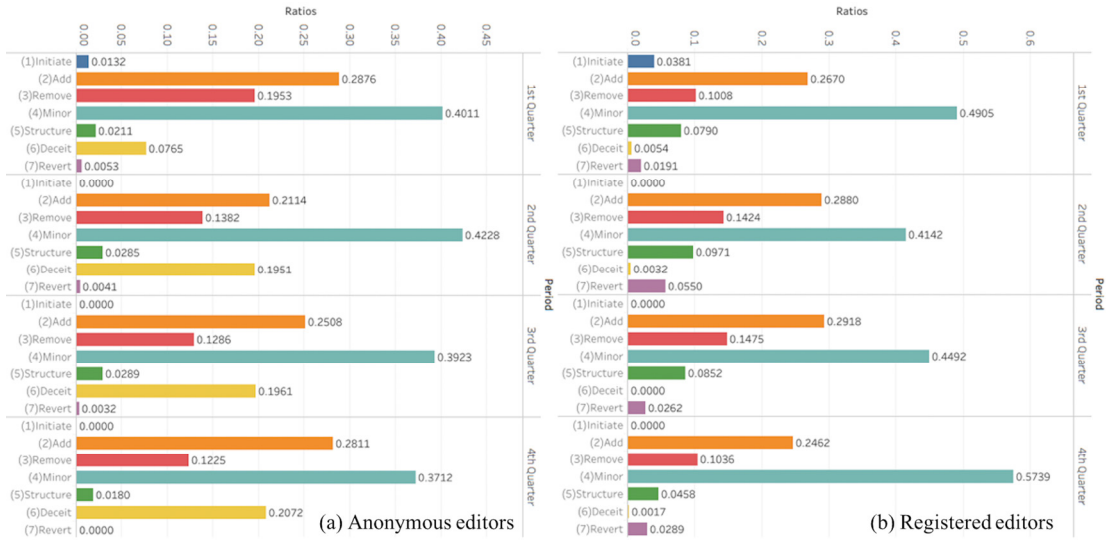
<Figure 2> Contributions by User Type

<Figure 3> shows the distribution of the contributions according to the time period of the articles. <Figure 3(a)> is for the anonymous editors, and <Figure 3(b)> is for the registered users.

The ratios of the deceits of the anonymous editors were very similar from the second to the fourth stages. Although the ratios of the first stage look different from the other stages, the contributions of the anonymous editors were similar across all stages. Whereas the contributions of the registered editors were similar from the first to the third stage, the ratios of the contributions in the fourth stage differed. The ratio of the minor edits increased, and the ratio of structuring edits decreased.

4.2. Variables

Standardized length of article and number of editors are used as control variables. For measuring anonymous participation, we used two variables – the ratio of anonymous users and the ratio of anonymous edits. The ratio of anonymous users is calculated as the total number of anonymous users in



<Figure 3> Contributions according to Period

an article is divided by the total number of users in the article. Since one anonymous user can edit multiple times, we also considered the ratio of anonymous edit. And the ratio of anonymous edit is calculated as the total number of edits done by anonymous users in an article is divided by the total number of edits in the article.

To measure the effects of anonymous participation according to the stages of online collaboration, we divided all edits of an article into 100 periods to standardize all the articles. For example, if one article has 1000 edits to become a featured article, one period is composed of 10 edits, and the article has 100 periods. We divided the 100 periods of all articles into two halves or four quarters. Then, we measured the ratio of anonymous edits each half or quarter. The ratio of anonymous edits for each half/quarter was the number of anonymous edits for the half/quarter divided by the total number of edits for the half/quarter. We used these two ratios of halves/four ratios of quarters as independent variables and used the duration of becoming a featured article as a dependent variable. <Table 4> shows the summary of the variables and their measurements.

Ⅴ. Analysis Results

Least-squares regression was applied at first with the dependent variable of the duration of becoming a featured article. The residuals did not follow a normal distribution, as assessed by the Shapiro-Wilk normality test, and showed heteroskedasticity, as tested with the Breusch-Pagan test. Thus, we used robust regression (MM-estimation) to overcome this.

<Table 5> shows the results of our empirical analysis. We used the 'lmRob' function in the robust package of 'R' (Wang et al., 2014). The R^2 values are in the bottom row of <Table 5>; all showed considerable values for the explanation. The VIF values for all models with least squares regression are lower than 10. Model 1 shows the results with only control variables: length of articles and number of editors. Although the coefficients of the control varia-

<Table 4> Basic Statistics of Variables

Variables	Mean	Standard deviation	Description	Measurement
Standardized Length of Article	0.000	1	Length of the current article	The count of English characters in an article. It takes a standardized form in the analysis.
Standardized Number of Editors	0.000	1	Number of editing participants	The number of editing participants in an article. It takes a standardized form in the analysis.
Ratio of anonymous users	0.295	0.188	The ratio of anonymous users	Proportion of anonymous users to the editing participants for an article.
Ratio of anonymous edits	0.139	0.134	The ratio of anonymous edits	Proportion of edits done by anonymous editors to the edits done by all participants for an article.
Ratio of anonymous edits for first half	0.182	0.170	The ratio of anonymous edits during the first half	Proportion of edits done by anonymous editors to the edits done by all participants for an article during the first half of the editing period of the current article.
Ratio of anonymous edits for second half	0.096	0.121	The ratio of anonymous edits during the second half	Proportion of edits done by anonymous editors to the edits done by all participants for an article during the second half of the editing period of the current article.
Ratio of anonymous edits for Q1	0.202	0.203	The ratio of anonymous edits during the first quarter	Proportion of edits done by anonymous editors to the edits done by all participants for an article during the first quarter of the editing period of the current article.
Ratio of anonymous edits for Q2	0.226	0.199	The ratio of anonymous edits during the second quarter	Proportion of edits done by anonymous editors to the edits done by all participants for an article during the second quarter of the editing period of the current article.
Ratio of anonymous edits for Q3	0.224	0.201	The ratio of anonymous edits during the third quarter	Proportion of edits done by anonymous editors to the edits done by all participants for an article during the third quarter of the editing period of the current article.
Ratio of anonymous edits for Q4	0.114	0.130	The ratio of anonymous edits during the fourth quarter	Proportion of edits done by anonymous editors to the edits done by all participants for an article during the fourth quarter of the editing period of the current article.

bles are positive, the variables have negative effects on the collaboration efficiency because it took longer to become a featured article if the article was longer and had more editors. Model 2 shows that the effect of the ratio of anonymous participants against total participants on a given article had a negative effect on the collaboration efficiency (positive coefficient of ratio of anonymous users). This indicates that the duration to become a featured article was longer if there were more anonymous users on the article. It was the same with the ratio of anonymous edits (number of edits by anonymous users) against total edits, as shown in Model 3. Thus, Hypothesis 1 was supported.

Model 4 shows the effects of the ratio of anonymous edits according to the stages of collaboration. The stages of article edits are divided in the first and second half according to the total number of edits. The results show that anonymous participation was negative in the first half (positive coefficient of ratio of anonymous edits for first half), but the effect of anonymous participation was not significant in the

<Table 5> Analysis Results

	Model 1	Model 2	Model 3	Model 4	Model 5
Standardized Length of Article	248.69*** (0.000)	208.63*** (0.000)	262.45*** (0.000)	242.46*** (0.000)	232.04*** (0.000)
Standardized Number of Editors	287.42*** (0.000)	82.36*** (0.000)	54.62** (0.008)	70.56*** (0.000)	79.89*** (0.000)
Ratio of anonymous users		1895.83*** (0.000)			
Ratio of anonymous edits			2421.06*** (0.000)		
Ratio of anonymous edits for first half				2010.45*** (0.000)	
Ratio of anonymous edits for second half				-25.43 (0.892)	
Ratio of anonymous edits for Q1					1,972.13*** (0.000)
Ratio of anonymous edits for Q2					-41.83 (0.785)
Ratio of anonymous edits for Q3					-58.85 (0.733)
Ratio of anonymous edits for Q4					356.08* (0.032)
R^2	0.2256	0.3131	0.2958	0.3086	0.3266

Note: The dependent variable for robust regression is Duration of becoming a featured article. * $p < 0.1$, ** $p < 0.01$, *** $p < 0.001$

second half.

Moreover, the stages of article edits are also divided into quarters, and the results are shown in Model 5. The ratios of anonymous edits for Q1 and Q4 had negative effects on the collaboration efficiency (positive coefficient of ratio of anonymous edits for Q1/Q4), although the coefficient of the ratio of anonymous edits for Q2 and Q3 were not significant. When there are more edits by anonymous users during Q1 and Q4, it takes longer to become a featured article. Although the ratios of anonymous edits for Q2 and Q3 were not significant, the ratios of anonymous edits for Q2 and Q3 had negative coefficient values. That means the variables don't have negative effect to the collaboration efficiency. Based on the results of Model 4 and 5, Hypothesis 2 was also supported.

We classified the articles into academic and non-academic based on the number of academic references. The references at the end of the articles were checked through the Web of Science. If there were at least one paper from the Web of Science, it was considered as an academic article. The test results for the academic and non-academic articles are represented in the Appendix as Table A1 (for academic articles) and A2 (for non academic articles). The results are similar to the results of the whole article as presented on <Table 5>.

Ⅵ. Discussion and Conclusions

In this article, we investigated how anonymous participation is associated with a duration to become a featured article during the different stages of collaboration. We found that anonymous participation, in terms of the ratio of anonymous users and edits, had negative effects on collaboration efficiency. However, the effects of anonymous participation on the collaboration efficiency were stronger in the earlier stage of article edits.

6.1. Theoretical Implications

These findings have several important implications for collaboration in online communities. Most past studies on anonymity in online communities have assumed that the effects of anonymous participations have one direction - positive or negative - on the performance of the collaboration (e.g., Kane 2011; Scott 2004; Tanis and Postmes 2007). We extended this and showed that the effects could vary, depending on the stage of collaboration. As Kane et al. (2009) identified, idea generation activities are usually done in the earlier stages, and style or refinement related activities are concentrated in the later stages of an article. Thus, we may infer that while structuring and generating ideas on knowledge, anonymous participation increases coordination costs and causes a delay in finishing up. However, the incoming of anonymous participation after the structure was fixed can be reverted easily by registered editors. And registered editors also exerted themselves to contribute minor editing in the later stage, as shown in <Figure 3(b)>.

6.2. Managerial Implications

The results of this study have implications for managers running community-based peer production environments or seeking to harness collective intelligence from online communities. These managers should consider the stages of collaboration when they encourage anonymous participation. Allowing anonymous participation is vital for lowering the barriers to participation. However, when members in online communities are trying to set up the structure of knowledge or in the earlier stages of building knowledge, anonymous participation is not helpful. Thus, these managers need to devise a mechanism to avoid anonymous participation in the stages for forming and structuring knowledge.

In this study, we found that anonymous participation is not beneficial to collaboration efficiency as a whole. However, lowering barriers to having 'enough eyeballs' and diversity in online communities can bring better results in knowledge creation (Arazy et al., 2011). Thus, managers need to design schemes to facilitate anonymous participation for increasing diversity, particularly in the middle stages, while curbing their deceitful behavior in knowledge formation and perfecting stages.

Ⅶ. Conclusions

This study has at least two limitations. First, we conducted this study entirely on the Wikipedia environment; additional research will be required for other types of online communities before the results can be generalized. Second, we focus on a set of high-quality articles on Wikipedia. Most articles initiated on Wikipedia never reach featured article status. Thus, further research will be meaningful to explore whether these findings apply to less organized and lower-performing communities.

Despite the limitations of this study, we make

meaningful contributions. It provides empirical evidence on the effects of anonymous participation on collaboration efficiency that differ according to the stage of online collaboration. While anonymous participation provides many eyeballs, at the same time, it increases coordination costs too. Thus, this study offers several insights that extend our understanding of anonymous participation in online communities and their effects on collaboration efficiency.

Acknowledgement

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2017S1A3A 2066740) and Hong Joo Lee was supported by the Research Fund, 2018 of The Catholic University of Korea.

<References>

[1] Anthony, D., Smith, S. W., and Williamson, T. (2009). Reputation and reliability in collective goods. *Rationality and Society, 21*(3), 283-306.

[2] Arazy, O., Nov, O., Patterson, R., and Yeo, L. (2011). Information quality in Wikipedia: The effects of group composition and task conflict. *Journal of Management Information Systems, 27*(4), 71-98.

[3] Balazs, A. L. (1990). Value congruency: The case of the 'socially responsible' firm. *Journal of Business Research, 20*(2), 171-181.

[4] Bales, R. F., and Strodtbeck, F. L. (1951). Phases in group problem-solving. *The Journal of Abnormal and Social Psychology, 46*(4), 485-495.

[5] Ball, P. (2007, February 27). The more, the wikier. *Nature News*, Available at: http://www.nature.com/news/2007/070226/full/news070226-6.html (Accessed 18 October 2017).

[6] Braaten, L. J. (1974). Developmental phases of encounter groups and related intensive groups. *Interpersonal Development, 5*(2), 112-129.

[7] Brown, S. L., and Eisenhardt, K. M. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative Science Quarterly, 42*(1), 1-34.

[8] Carr, N. G. (2007). The ignorance of crowds. *Strategy +Business* (Issue 47), Available at: https://www.strategy-business.com/article/07204?gko=6c4ad (Accessed 18 October 2017)

[9] Di Gangi, P. M., Wasko, M. M., and Hooker, R. E. (2010). Getting customers' ideas to work for you: Learning from dell how to succeed with online user innovation communities. *MIS Quarterly Executive, 9*(4), 213-228.

[10] Faraj, S., Jarvenpaa, S. L., and Majchrzak, A. (2011). Knowledge collaboration in online communities. *Organization Science, 22*(5), 1224-1239.

[11] Gallaugher, J., and Ransbotham, S. (2010). Social media and customer dialog management at Starbucks. *MIS Quarterly Executive, 9*(4), 197-212.

[12] Gersick, C. J. G. (1988). Time and transition in work teams: Toward a new model of group development. *Academy of Management Journal, 31*(1), 9-41.

[13] Gersick, C. J. G. (1991). Revolutionary change theories: A multilevel exploration of the punctuated equilibrium paradigm. *Academy of Management Review, 16*(1), 10-36.

[14] Hayne, S. C., Pollard, C. E., and Rice, R. E. (2003). Identification of comment authorship in anonymous group support systems. *Journal of Management Information Systems, 20*(1), 301-329.

[15] Jessup, L. M., and Tansik, D. A. (1991). Decision making in an automated environment: The effects of anonymity and proximity with a group decision support system. *Decision Sciences, 22*(2), 266-279.

[16] Jessup, L. M., Connolly, T., and Tansik, D. A. (1990). Toward a theory of automated group work the

deindividuating effects of anonymity. *Small Group Research, 21*(3), 333-348.

[17] Kane, G. C. (2011). A multimethod study of information quality in wiki collaboration. *ACM Transactions on Management Information Systems, 2*(1), 4.

[18] Kane, G. C., Majchrzak, A., and Johnson, J. (2009). A longitudinal model of perspective making and perspective taking within fluid online collectives. *In Proceedings of International Conference on Information Systems 2009*, Phoenix, AZ.

[19] Kelley, J. B., and Alden, D. L. (2016). Online brand community: Through the eyes of self-determination theory. *Internet Research, 26*(4), 790-808.

[20] Lacoursiere, R. (1974). A group method to facilitate learning during the stages of a psychiatric affiliation. *International Journal of Group Psychotherapy, 24*(3), 342-351.

[21] Malone, T. W., and Klein, M. (2007). Harnessing collective intelligence to address global climate change. *Innovations, 2*(3), 15-26.

[22] Marx, G. T. (1999). What's in a name? Some reflections on the sociology of anonymity. *The Information Society, 15*(2), 99-112.

[23] Nunamaker Jr, J. F., and Dennis, A. R. (1991). Information technology for negotiating groups: Generating options for mutual gain. *Management Science, 37*(10), 1325-1346.

[24] O'Reilly, C. (1989). Corporations, culture, and commitment: Motivation and social control in organizations. *California Management Review, 31*(4), 9-25.

[25] Park, H. J., and Park, S. J. (2016). Communication behavior and online knowledge collaboration: Evidence from Wikipedia. *Journal of Knowledge Management, 20*(4), 769-792.

[26] Petty, R. E., and Cacioppo, J. T. (1986). *Communication and persuasion: Central and peripheral routes to attitude change*. Springer, New York, NY.

[27] Rains, S. A. (2007). The impact of anonymity on perceptions of source credibility and influence in computer-mediated group communication: A test of two competing hypotheses. *Communication Research, 34*(1), 100-125.

[28] Ransbotham, S., and Kane, G. C. (2011). Membership turnover and collaboration success in online communities: Explaining rises and falls from grace in Wikipedia. *MIS Quarterly, 35*(3), 613-627.

[29] Ransbotham, S., Kane, G. C., and Lurie, N. H. (2012). Network characteristics and the value of collaborative user-generated content. *Marketing Science, 31*(3), 387-405.

[30] Rao, V. S., and Jarvenpaa, S. L. (1991). Computer support of groups: Theory-based models for GDSS research. *Management Science, 37*(10), 1347-1362.

[31] Raymond, E. S. (1999). *The cathedral and the bazaar*. O'Reilly Media, Sebastopol, CA.

[32] Scott, C. R. (2004). Benefits and drawbacks of anonymous online communication: Legal challenges and communicative recommendations. *Free Speech Yearbook, 41*(1), 127-141.

[33] Scott, J. C. (2007). *The difference: How the power of diversity creates better groups, firms, schools and societies*. Princeton University Press, Princeton, NJ.

[34] Seeger, J. A. (1983). No innate phases in group problem solving. *Academy of Management Review, 8*(4), 683-689.

[35] Seigenthaler, J. (2005, November 29). A false Wikipedia biography. *USA Today*, Available at http://usatoday30.usatoday.com/news/opinion/editorials/2005-11-29-wikipedia-edit_x.htm (Accessed 18 October 2017)

[36] Shao, G. (2009). Understanding the appeal of user-generated media: A uses and gratification perspective. *Internet Research, 19*(1), 7-25.

[37] Sia, C. L., Tan, B. C. Y., and Wei, K. K. (2002). Group polarization and computer-mediated communication: Effects of communication cues, social presence, and anonymity. *Information Systems Research, 13*(1), 70-90.

[38] Spears, R., and Lea, M. (1992). Social influence and the influence of the 'social' in computer-mediated communication. In M. Lea (ed.), *Contexts of computer-mediated communication* (pp. 30-65).

Harvester-Wheatsheaf, London, UK.

[39] Tanis, M., and Postmes, T. (2007). Two faces of anonymity: Paradoxical effects of cues to identity in CMC. *Computers in Human Behavior, 23*(2), 955-970.

[40] Tuckman, B. W. (1965). Developmental sequence in small groups. *Psychological Bulletin, 63*(6), 384-399.

[41] Tuckman, B. W., and Jensen, M. A. C. (1977). Stages of small-group development revisited. *Group & Organization Management, 2*(4), 419-427.

[42] Wilkinson, D. M., and Huberman, B. A. (2007). Assessing the value of cooperation in Wikipedia. *First Monday, 12*(4). Available at http://firstmonday.org/article/view/1763/1643 (Accessed 18 October 2017)

[43] Wöhner, T., Köhler, S., and Peters, R. (2011). Automatic reputation assessment in Wikipedia. *In Proceedings of International Conference on Information Systems 2011 in Shanghai*, China.

<Appendix>

The references of the featured articles were checked through the Web of Science. If there were at least one paper from the Web of Science, it was considered as an academic article. In this way, we classified the articles into academic and non-academic based on the number of academic references. The test results for the academic and non-academic articles are represented in <Table A1> (for academic articles) and <Table A2> (for non academic articles). The results are similar to the results of the whole article as presented on <Table 5>.

<Table A1> Analysis Results with Academic Articles

	Model 1	Model 2	Model 3	Model 4	Model 5
Standardized Length of Article	170.92*** (0.000)	82.04* (0.000)	71.12 (0.070)	185.21*** (0.000)	106.54*** (0.000)
Standardized Number of Editors	368.83*** (0.000)	70.35 (0.153)	250.33*** (0.000)	-19.84 (0.733)	102.46** (0.000)
Ratio of anonymous users		2723.84*** (0.000)	6778.22*** (0.000)		
Ratio of anonymous users^2			-7566.20*** (0.000)		
Ratio of anonymous edits				3698.79*** (0.000)	9498.51*** (0.000)
Ratio of anonymous edits^2					-15833.95*** (0.000)
R^2	0.2259	0.379	0.4136	0.3507	0.4088

<Table A2> Analysis Results with Non Academic Articles

	Model 1	Model 2	Model 3	Model 4	Model 5
Standardized Length of Article	250.53*** (0.000)	215.83*** (0.000)	201.93*** (0.000)	262.35*** (0.000)	229.06*** (0.000)
Standardized Number of Editors	272.79*** (0.000)	91.39*** (0.000)	237.30*** (0.000)	67.56** (0.002)	141.65*** (0.000)
Ratio of anonymous users		1718.17*** (0.000)	5368.00*** (0.000)		
Ratio of anonymous users^2			-6540.64*** (0.000)		
Ratio of anonymous edits				2203.32*** (0.000)	6553.44*** (0.000)
Ratio of anonymous edits^2					-11062.56*** (0.000)
R^2	0.2205	0.3006	0.3454	0.2868	0.3331

◆ About the Authors ◆

Hong Joo Lee

Hong Joo Lee is a Professor of Business Administration at the Catholic University of Korea. He has a Ph.D. from the KAIST Business School (2006) and was with the MIT Center for Coordination Science as a postdoctoral fellow in 2006. He stayed at the MIT Center for Collective Intelligence as a visiting scholar in 2011 and was at the Brunel Business School, Brunel University as an international researcher in 2017－2018. His research areas are utilizing intelligent techniques and analyzing effects of intelligent aids in digital business. His papers have been published in International Journal of Electronic Commerce, Decision Support Systems, Expert Systems with Applications, Journal of Electronic Commerce Research, Cyberpsychology, Behavior and Social Networking, Information Systems Frontiers, and other journals.

Jong Woo Kim

Jong Woo Kim is a professor at the School of Business, Hanyang University, Seoul, Korea. He received B.S. degree from the Department of Mathematics at Seoul National University, Seoul, Korea. He received his M.S. and Ph.D. degrees, respectively, from the Department of Management Science, the Department of Industrial Management at Korea Institute of Science and Technology (KAIST), Korea. His current research interests include intelligent information systems, data mining applications, social network analysis, text mining application, collaborative systems, and e-commerce recommendation systems. His papers have been published in Expert Systems with Applications, Cyberpsychology Behavior and Social Networking, Computers in Human Behavior, Information Systems Frontiers, International Journal of Electronic Commerce, Electronic Commerce Research, Mathematical and Computer Modeling, Journal of Intelligent Information Systems, and other journals.

Hyun Jung Park

Hyun Jung Park is a research professor at the Management Research Center, Ewha Womans University, Seoul, Korea. She earned her B.S. and M.S. degrees in Management Science from the Korea Advanced Institute of Science and Technology (KAIST), and a Ph.D. in Management Information Systems from the Seoul National University. Her research interests include virtual knowledge collaboration, big data analytics, artificial intelligence, social network analysis, and business intelligence. Her papers have been published in Knowledge-Based Systems, Information Processing & Management, Journal of Knowledge Management, Journal of Database Management, Cyberpsychology Behavior and Social Networking, and other journals.

Sung Joo Park

Sung Joo Park is a Professor of Information Systems at the KAIST Graduate School of Management in Seoul, Korea. He holds a B.S. degree in Industrial Engineering from the Seoul National University, an M.S. in Industrial Engineering from the Korea Advanced Institute of Science, and a Ph.D. in Systems Science from the Michigan State University. He has been a senior researcher at the Software Development Center, KIST, and a professor at the KAIST since 1980. His areas of research interests include intelligent information systems and the application of agent technology to management decision-making.

Submitted: July 19, 2019; 1st Revision: December 14, 2019; 2nd Revision: April 8, 2020; Accepted: April 13, 2020