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The Effect of Network Position on the Efficiency of Open Collaboration: A Study of Wikipedia Featured Article Edits

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ABSTRACT

The success of Wikipedia is due to the large number of volunteers collaborating to provide content to Wikipedia articles. In this paper, we study the effect of network position on the promotion of an article to a featured article. We focus on the edits of featured Wikipedia articles to study the effects of the centrality of editors and centrality of articles on the promotion of featured articles. Considering the editing precedence among editors within an article, editor collaboration networks for a single article are generated using the total English-written featured articles on Wikipedia. In addition, based on the affiliation network of editors and articles, an article-to-article network and an editor-to-editor collaboration network are constructed. Based on the investigation of the networks, we find that article centrality in an article-to-article network has a negative effect on the promotion of an article, and editor centrality in an article-to-article networks has a positive effect on promotion. In addition, editor centrality in an editor-to-editor network has a negative effect on promotion. Some theoretical and managerial implications are provided in view of these results.

Keywords: Wikipedia, Featured Articles, Network Position, Centrality, Efficiency, Article Promotion

Ⅰ. Introduction

Web 2.0 technologies are important tools for online collaboration. In recent years, we have experienced an upward trend of using web 2.0 technologies to enhance online collaboration, work performance and outcomes (Bélanger and Allport, 2008; Carte and Chidambaram, 2004; Easley et al., 2003; Kwon and Kim, 2010). Internet-based collaboration technologies that support and enable online collaboration among members of organizations and online collaboration sites for collective content sharing (Borgatti

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and Foster, 2003) and knowledge co-creation have captured the attention of many organizations and enterprises (Borgatti and Foster, 2003; Joo and Normatov, 2012; Ju and Hwang, 2016; Menchen-Trevino et al., 2009). These online collaboration platforms have adopted the concept of wiki collaboration to facilitate teamwork and knowledge collaboration.

Online content collaboration sites have attracted the attention of both researchers and business leaders. Researchers are interested in investigating the process of social collaboration and the effect of network structure on the success of online collaboration (Karna and Ko, 2013; Menchen-Trevino et al., 2009; Ransbotham and Kane, 2011; Singh, 2010; Wilkinson and Huberman, 2007). Academic researchers who have studied the effect of network position on performance or efficiency have determined the mechanism through which the outcomes of online mass collaboration projects are highlighted. This line of academic findings describes collaborative affiliations as networks of actors and considers the structural properties of these networks to study the effect of network structure on performance, knowledge flow between the nodes for seeking information, and getting help from Wikipedia.

Wikipedia is an online collaboration platform for voluntary contributors who access and edit to improve the content of articles in an online encyclopedia format. A Wikipedia article is promoted to a featured article when it is considered one of the best articles according to reviews by a large number of Wikipedia editors and is used as an example for writing other articles. Studies on social capital and network structure have found that the structure of social networks greatly affects the dynamics of information and knowledge seeking and flow within a network (Burt, 2004; Coleman, 1988; Granovetter, 1973). Wikipedia editors with higher centrality tend to contribute more (Zhang and Wang, 2012). Content development is affected by the accessibility and diversity of editor knowledge resources available for online collaboration (Fleming, 2001). Access to these resources and diversity of editor knowledge and skills affect the content of Wikipedia articles (Arazy et al., 2011); when there is greater access to these resources and more diverse editor knowledge, editors in the community are better able to provide novel ideas and content. Wikipedia editors having access to the content of a large number of other articles helps the community of editors search for relevant content.

Most of the studies on the relationship between network structure and online collaboration in Wikipedia have been done in article level analysis. They calculated centrality or other measures from an article and computed average values for their sample articles. However, many editors participate in diverse articles and the global network structure of editors or articles can be drawn from whole articles. With the global networks of editors and articles, we can see the more broad view of collaborations among editors.

Thus, we extend the current line of research on network structure and online collaboration by investigating the global network of editors and articles. This study aims to investigate the effect of global and local network position on online collaboration. We focus on the effects of network position on the efficiency of online content collaboration. By contributing many articles, editors can have interactions with other editors who have diverse knowledge. These different interactions can be identified with the global network. The efficiency of online collaboration is measured as the performance of online collaboration. Many interactions with other editors can increase knowledge available and augment diverse perspectives for online collaboration. It also incurs coor-

dination costs among editors. Thus, we control the quality of collaboration they achieved by using the featured articles from Wikipedia. So we investigate the effect of network position on the duration of reaching a featured article level. We apply social network analysis measures such as degree centrality to determine the effect of network structure on the efficiency of an article becoming a featured article. We measure the centrality of editors to a single article (local centrality) and multiple articles (global centrality).

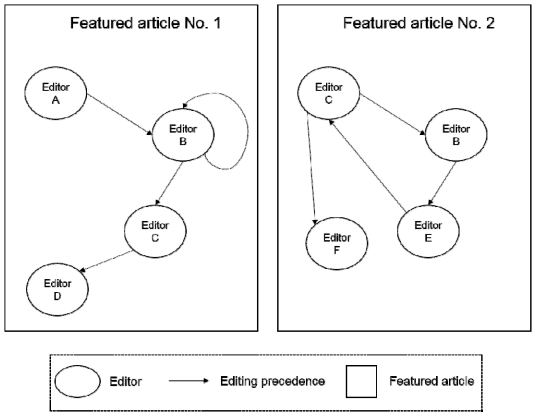
The rest of the paper is structured as follows. Section 2 includes a literature review of previous studies, which includes a discussion of collaboration networks of articles and editors. Then, the data collection and methodology are described in the context of model specification, the variables are defined, and the results are presented. Finally, a discussion and limitations of this study are presented along with directions for future research.

Ⅱ. Literature Review

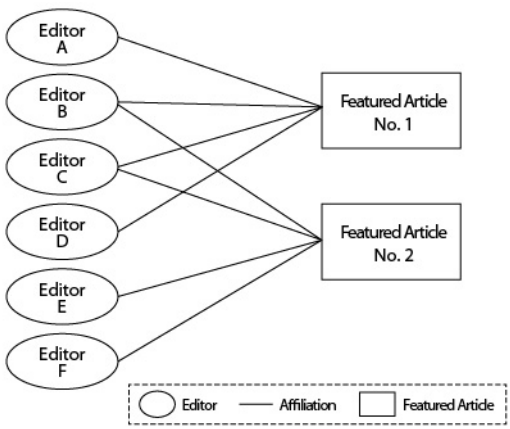
2.1. Wikipedia Article Editors' Collaboration Networks

An article originates when a member of the Wikipedia community initiates the article and it evolves incrementally through the edits of voluntary editors (Wagner and Bolloju, 2004). As shown in <Figure 1>, editors have precedence relationship among editors by editing an article which had been edited by another editor.

Editors in Wikipedia work on diverse articles at different times and hence belong to multiple article editing networks, creating an affiliation network of editors and articles that represents the affiliation between a set of specific actors and social relationship (Wasserman and Faust, 1994). The editing relationships depicted in <Figure 1> can be represented as <Figure 2>. Editor A, B, C and D have relationship with Article No. 1 and Editor B, C, E and F also have relationship with Article No. 2.



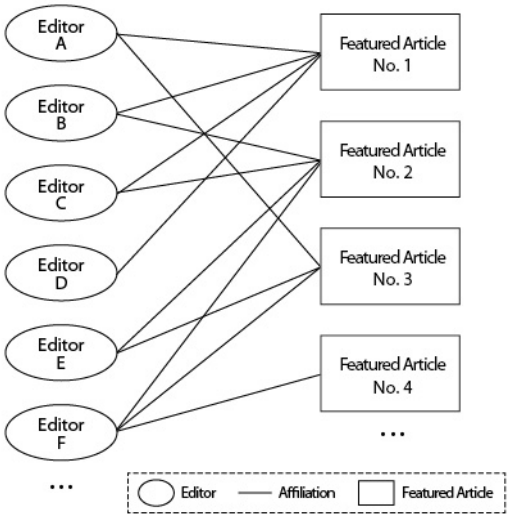
<Figure 1> Single Article Editor Networks



<Figure 2> Multiple Article Editor Network

As represented in <Figure 2>, we can draw a global network of editors and articles as shown in <Figure 3>.

From <Figure 3>, we can extract affiliation editor network and affiliation article network as depicted in <Figure 4(a)> and <Figure 4(b)>. The affiliations



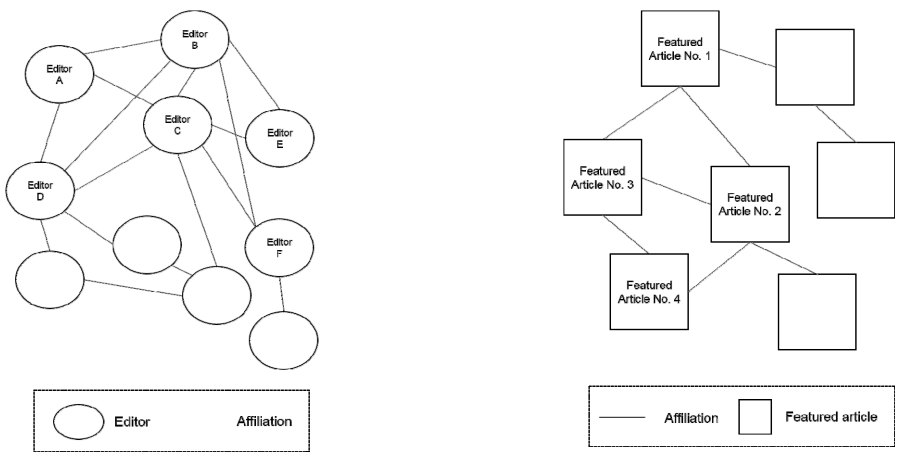
<Figure 3> Global Network of Editors and Articles

in the editor-to-editor network are editing same article and the affiliation in the article-to-article network are edited by same editor. From the example in <Figure 2>, Editor A and D have participated in editing for featured article No. 1. Thus, Editor A and D have an affiliation in the editor-to-editor network. Also, both of the featured article No. 1 and No. 2 are edited by Editor B. This turns into an affiliation in the article-to-article network.

Editors connect with each other by contributing to articles of interest to them, and their connections and ties are expanded when they contribute to additional articles. Based on the global network of editors and articles, we can generate an editor-to-editor network and an article-to-article network. In this paper, the editor-to-editor network is called the affiliation editor network, and the article-to-article network is called the affiliation article network (refer <Figure 4>).

2.2. Social Network and Performance

Various researchers have examined the social behavior of individuals in organizations based on social capital and network theories. Nahapiet and Ghoshal (1998) described social capital as consisting of both network structure and the potential resources that flow through that network structure (Nahapiet and Ghoshal, 1998). According to them, social capital is the set of relationships that are embedded in the network's ties. They defined social capital as the *"sum of the definite and potential resources rooted within, accessible through and resulting from the network of*



a. Affiliation Editor Network

b. Affiliation Article Network

<Figure 4> Affiliation Network

associations possessed by individuals or social units." A number of studies have relied on social capital and network theories to examine the effect of social capital on knowledge sharing, contribution and learning (Gibson and Vermeulen, 2003; Hansen, 2002; Kankanhalli et al., 2005). Grewel et al. (2006) found that social capital affects project success through network centrality. Other scholars have uncovered network factors associated with performance in organizations and intergroup conflicts (Labianca et al., 1998).

The centrality of a node is considered an important factor that has been employed to assess behavior in an open collaboration (Wasserman and Faust, 1994). If a person is central, having the largest number of direct ties with other members in the network, he or she will have more access to information and will be popular among other members in the network. The centrality of a node in a cohesive collaboration network is helpful in promoting knowledge sharing and knowledge shaping. Well-positioned editors boost their edits and resources because occupying a central position enhances access to resources, favors and references (Rowley et al., 2000; Walker et al., 1997).

Singh (2010) and Coleman (1988) found that internal cohesion among the members of an online mass collaboration affects the success of their collaboration (Coleman, 1988; Singh, 2010). Intergroup cohesiveness of team members means that they share common values, norms and culture (Reagans and McEvily, 2003; Szulanski, 1996; Uzzi, 1997). Members with a strong cohesion will form a shared understanding of how to solve a problem and provide valuable information for the solution. Burt (2004), however, found that too much cohesion among mass collaboration project members has negative effects on the success and efficiency of the work (Burt, 2004). He argued that the thinking and problem-solving skills of the members are similar and they tend to think in similar ways, overlooking the possibility of alternate ways to solve a problem. Therefore, he insisted that very cohesive groups can sometimes perform very poorly, as they neglect important information that does not match their thinking and hence overlook alternatives in their innovation of ideas.

The diversity of one's knowledge base is considered to be positively related to achieving new ideas and skills, and hence performance. The diversity of an editor's knowledge base will, however, become difficult to manage and can create conflicts or edit wars when there is mistrust and miscommunication amongst Wikipedia editors. Coleman (1988) proposed that diversity in the editors' knowledge base and skills will lead to conflict over the content, and so can negatively affect the editing process for Wikipedia. The centrality and diversity of editors are related to editors absorbing the knowledge shared and learning new ideas by comparing or associating them with what they have previously learned[24]. Scholars who have studied diversity have mentioned both its positive and negative effects on performance, stating that diversity has a two-sided effect on performance depending on the condition for the studies (Harrison and Klein, 2007; Horwitz and Horwitz, 2007).

Ⅲ. Research Model and Hypothesis Development

Wikipedia articles differ in terms of the content and editors; articles involve editors with diverse knowledge bases and expertise, contributing their knowledge to the article editing community. Having

a great number of editors provides opportunities for the editors to gain and contribute knowledge, access different content, test their editing skills and learn from the experience of others. This process fosters editors' creativity and provides new solutions to problems (Sampson, 2007). However, editors with more diverse knowledge will intensify the number of possible rearrangements to an article, which may give way to information overload. Sometimes, important and interesting content requires a consensus among the editors, which can take time.

As discussed before, diverse content and editors with different backgrounds and diverse knowledge bases will influence performance negatively. Knowledge contributors accept content that aligns with their related knowledge and experiences (Cohen and Levinthal, 1990). They will not accept anything that contradicts either their existing knowledge or their intention to contribute to Wikipedia. Articles that are highly attractive to editors will sometime cause conflicts among the editors. The contributors to these articles bring different sets of knowledge and skills to the collaboration. Editors with diverse knowledge and skills may create conflicts over the content of an article and start an edit war among the editors that will have a negative effect on the progress of an article. Similarly, articles that are central among the editors are susceptible to the negative effect of an ego booster, an editor who simply contradicts other points of view to show his or her presence in the collaboration network (Ahuja et al., 2012; Borgatti and Foster, 2003; Payne et al., 2011). Based on the above arguments and discussion, we propose our hypothesis as follows.

H1: Article centrality in the affiliation article network will have a negative impact on the efficiency of an article.

The centrality of a node has a correlation with its performance within a certain network boundary. The centrality of an editor in the affiliation editor network (refer <Figure 4(a)>) is defined based on its ties with other editors in the community, which measure how the editors exchange information and are affiliated with each other in an editing network. An individual who is central in the network can influence the efficiency of an article by virtue of his or her links with a large number of people in the network, which means that a particular editor can receive information from other members of the editing community. Hence, a greater number of direct relationships with other nodes is important for promoting knowledge sharing in the editor community. Thus, editor centrality is a kind of informal power, as central editors have access to various resources and knowledge bases (Burt, 2004). Editors with a higher number of ties bring other editors to contribute to the articles, and they also have the opportunity to access editors' diverse knowledge and learn from others' experiences. Ties that break through physical barriers increase opportunities to information and have a positive impact on knowledge creation and open collaboration efficiency (Desantics and Monge, 1998). Similarly, the literature allows central editors to become popular and thus gaining the attention of others, which makes them contribute more effective content (Wasserman and Faust, 1994). Based on the argument provided above, we state that the existence of editors with high centrality in a single network (refer <Figure 1>) influences the efficiency of articles.

H2: The existence of an editor with high centrality within a single article editor network positively impacts the efficiency of the article.

According to Singh (2010) and Coleman (1988), internal cohesion among project members means that they create common values, norms and a culture of supporting and understanding the content provided by members of the network. Singh (2010) captured internal cohesion as the average of the repeated ties between two editors in a content developing network who have worked together. He stated that internal cohesion among the members in a single network develops willingness and motivation among the editors to share knowledge and invest time and energy in shaping the knowledge they provide (Reagans and McEvily, 2003; Singh, 2010; Szulanski, 1996; Uzzi, 1997). Editors with a strong cohesion with other editors will create a shared understanding of a problem and provide solutions to the problem, which facilitates learning and communication and helps knowledge creation. According to network theory, ties with a strong interaction will reflect shared experiences that facilitate collaboration, trust, and social support. Furthermore, the theory predicts that ties with a high number of interactions with other members will provide insight into the level of diverse and redundant resources available based on the pattern of ties among editors (Borgatti and Halgin, 2011; Burt, 2004; Fleming, 2001; Uzzi, 1997). However, scholars have argued that too much cohesion can lead to poor performance. They stated that too much cohesion among groups or project members can mean that they overlook new ways of creating knowledge and collaborating, which leads to poor performance and no new innovative ideas. Therefore, based on the discussion above, we develop our hypothesis as follows: the average centrality of editors within a single network of editors (refer <Figure 1>) will have a positive effect on the duration of time it takes for an article to become a featured article.

H3: The average centrality of editors within a single article editor network will have a positive and curvilinear effect on the efficiency of an article.

On the one hand, editors involved in knowledge collaboration networks benefit from their ties with others, but on the other hand, having a large number of ties will severely limit the editor's ability to pursue new opportunities in a dynamic environment because of the attention and resources required to maintain existing ties within a network. Keeping too many ties will lead to information overload (Ibarra and Andrews, 1993). Similarly, editors' ties with a diverse set of editors will test their social collaboration skills as well as their knowledge and experience. If the collaboration takes on the shape of mistrust and miscommunication, it will create conflicts over content as well as with other editors, as editors with different knowledge bases and collaboration skills will force their ideas upon the editing community, which can start an edit war between clusters of editors.

The existence of editors who have high centrality in the affiliation editor network negatively influences the efficiency of articles. Editors from different networks with different knowledge bases will try to share their content and diverse knowledge bases and skills. Therefore, they will contradict each other's knowledge and engage in conflicts over the content of articles. Iba et al. (2010) suggested that an ego booster will simply contradict the content to enforce his or her presence in the network and hence negatively influence the efficiency of the article. Similarly, one scholar stated that conflict of different knowledge bases will create conflicts of expertise among the editors (Coleman, 1988). He proposed that diversity in content means that it is shared by people with diverse baseline knowledge and skills, so the diversity in skills and knowledge base will lead to conflicts

and challenges to share knowledge with the communities. Content contributed from diverse areas may create professional conflicts and lead to an edit war.

In addition, a central editor absorbs knowledge from other editors. Individuals learn new ideas by associating them with what they already know (Reagans and McEvily, 2003). Sometimes the access to more diverse sources and bases of information becomes difficult to manage, and the contributors adopt a tendency to overlook new ideas because their thinking is saturated. In addition, for the collaboration process, the editors' relationship becomes too cohesive and they adopt a tendency to perform poorly and overlook opportunities to think innovatively (Burt, 2004). The above discussion leads us to our hypothesis about the centrality of editors in affiliation editor networks (refer <Figure 4(a)>).

H4: The existence of editors with high centrality in the affiliation editor network will have a negative impact on the efficiency of an article.

H5: Average editor centrality in the affiliation editor network will have a negative impact on the efficiency of an article.

Ⅳ. Research Methodology

In this paper, we gather data related to featured articles and editors associated with English articles from Wikipedia. Only editors registered with Wikipedia are considered for the data analysis. Specifically, we gather data regarding the editing histories of 2,978 featured articles out of more than 3 million articles. We filter out the data of anonymous editors and edits done by bots.

With the editor and article relationship in the data, we create an affiliation editor network; that is, editors who edit the same article, are in a knowledge-sharing relationship, and thus have a tie with each other. Similarly, we create an affiliation article network, which includes articles that are edited by the same editors and thus have a tie to each other (refer to <Figure 4(b)>). In addition, based on editing precedence among the editors within a single article, we generate a single article editor network (refer <Figure 1>).

Our dependent variable is the duration (time) it takes an article to be promoted to a featured article. This duration of article promotion to a "featured article" status depends upon the knowledge creation in the Wikipedia article that follows an incremental line of editing and knowledge sharing, network position, and benefits from the establishment of networks (Gulati and Gargiulo, 1999). Therefore, we measure the time it takes for an article to become a featured article in days as the efficiency of collaboration.

We calculate the degree of centrality of the single article editor network. We use the Igraph package in R for measuring the centrality of an editor. From single article editor networks, we choose the editor who has the highest centrality among the editors in the articles, and we calculate the average degree of centrality of the editors in a single article editor network. In addition, for the affiliation editor network, degrees of centrality of editors are calculated, and based on the degrees, we select the highest and average centrality in the whole network. Similarly, from the affiliation article networks, the degree of centrality of the articles is calculated.

Previous studies have investigated the relationship between the outcome and quantity of edits. Wilkinson and Huberman (2007) states that a higher number of edits may negatively influence the performance

<Table 1> Pretest Analysis for Choosing the Regression Model

Assumption	Testing criteria used	Condition	Stats	Result
Normality	Jarque-Bera test	Normal if p-value > 0.05, otherwise not normal	p-value < 0.05	Non-normality
Multicollinearity	Condition index	Collinear if Condition index > 15	Condition index = 32.4	Presence of multicollinearity
Homoscedasticity	White test	If p-value > 0.05 homoscedasticity, otherwise not homoscedasticity	p-value < 0.05	Presence of heteroscedasticity

of teams, leading to conflicts and edit wars. In this study, we use total number of edits as a control variable. Knowledge contribution is measured as the total number of edits on the articles. A larger number of edits means that editors will require more time to look at the history of the edits. Understanding the content of the edits will have a negative effect on the efficiency of the article but in contrast will improve the quality of the article, so we control for the total number of edits.

Our next control variable is article length; we measure the length of an article by simply looking at the size it occupies (in bytes). A larger size means that the article has more information and more edits from the editors, so we use article length as a control variable. To measure the human capital involved in the article knowledge collaboration, as a control variable, we include the total number of editors involved in the article editing and knowledge contribution. We include only those editors with known identities and remove bots for counting the number of nodes. Though many unregistered editors participated in several times, they usually edit once in an article. It is complicated to include the unregistered editors for drawing collaborative networks, and they usually are not collaborative. Thus, we exclude the edits done by the unregistered editors.

In our initial investigation about the model specification and variables, some of the independent variables show a skewed distribution, so we logarithmically transform three of our independent variables because the results in such cases (i.e., non-normal cases) can be biased (Gelman and Hill, 2007). Before running the model for the analysis, we also perform a pretest analysis for multiple linear regressions for checking the assumption validity as shown in <Table 1>. The residuals did not follow a normal distribution, as assessed by the Jarque-Bera normality test, and showed heteroskedasticity, as tested using the White test. The result for multicollinearity test shows the presence of muliticollinearity. Thus, robust regression (MM-estimation) was used to overcome this. We only include three control variables in our analysis for the heterogeneity of the model. However, there may be some effects that we look over, as we do not include variables such as motivation, characteristics, market, or human ability (Singh, 2010). That said, in our case Wikipedia articles are not market driven as a whole; it is a volunteer process in which editors upload the content for further discussion and queries. Therefore, there are no market-driven motives or factors affecting the content contribution and collaboration.

Ⅴ. Data Analysis and Results

<Table 2> contains the results of the regression

<Table 2> Robust Regression Using Average Centralities

Variable name	Model 1	Model 2	Model 3	Model 4
Total number of edits	-193.51*** (30.35)	-15.32*** (8.41)	-16.40*** (8.40)	-16.80*** (8.37)
Number of editors	548.15*** (21.93)	38.1*** (6.68)	38.53*** (6.61)	38.33*** (6.56)
Article length	261.62*** (34.84)	18.83*** (9.60)	17.94*** (9.54)	18.04*** (9.48)
Article centrality		0.15** (0.18)	0.16*** (0.18)	0.16*** (0.17)
Average editor centrality (single network)			-0.76*** (0.17)	0.352 (0.41)
Average editor centrality (global network)			0.25 (0.23)	0.247 (0.23)
Average editor centrality_ squared (single network)				0.008** (0.23)
R^2	0.4409	0.4426	0.4469	0.4478

Note: Significant Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1, standard errors are enclosed in brackets

analysis using the average editor centralities, and <Table 3> contains those of the regression analysis using the maximum editor's centrality. We use robust regressions for our analysis. We log-transform our independent variables after our pretest analysis and compare the results with results without log-transformation. Model 1 in both <Table 2> and 3 contains only the control variables. The article centrality variable is added in Model 2, and Model 3 contains all the variables of Model 2 with the addition of editor centralities in multiple article editor network and single article editor networks for both average and maximum centrality measures. In Model 4 in <Table 2>, we add the square term of the average editor's centrality variables within a single article editor network.

We refer to Models 3 and 4 in <Table 2> and Model 3 in <Table 3> for our discussion of the model results. We focus on Models 3 and 4 in <Table 2> for Hypotheses 1, 3 and 5 and Model 3 in <Table 3> for Hypotheses 2 and 4.

The results of both Model 4 in <Table 2> and Model 3 in <Table 3> support Hypothesis 1. Article centrality has a negative effect on efficiency (duration), and the results are significant and in the expected direction (0.16, $p < 0.05$). Similarly, the results of Model 3 and Model 4 in <Table 2> support Hypothesis 3, which states that editors' average centrality in a single article editor network has a positive and curvilinear impact on the efficiency (duration). The results are significant and in the expected direction (-0.76, $p < 0.05$), and the squared average centrality is significant and in the expected direction (0.008, $p < 0.05$). Hypothesis 5 posits that average editor centrality in multiple article editor network is not supported. Model 3 in <Table 3> supports Hypothesis 2, that the existence of central editors in a single article editor network will positively impact the efficiency of an article. The coefficient is significant and in the expected direction (β = -1.28, $p < 0.05$,

<Table 3> Robust Regression for Maximum User Centrality Measures

Variable name	Model 1	Model 2	Model 3
Total number of edits	-193.51*** (30.35)	-15.32*** (8.41)	-17.31 (9.13)
Number of nodes	548.15*** (21.93)	38.1*** (6.68)	29.98*** (7.24)
Article length	261.62*** (34.84)	18.83*** (9.60)	17.31*** (9.34)
Article centrality		0.15** (0.18)	0.58*** (0.23)
Maximum centrality of editors (single network)			-1.28*** (0.47)
Maximum centrality of editors (global network)			0.07** (0.10)
R^2	0.4409	0.4426	0.4636

Note: Significant Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1, standard errors are enclosed in brackets

the negative sign represents a positive impact). Similarly, Hypothesis 4 is also supported, and the coefficient is significant and in the expected direction ($\beta = 0.07$, $p < 0.05$).

Ⅵ. Discussion and Conclusion

Our findings that both average centrality and maximum centrality of editors in a single network have a positive effect on the efficiency of collaboration, are in line with the results of Singh (2010). Similarly, article centrality has a negative effect on the efficiency of collaboration, as content edited from different perspectives with different editing skills and knowledge bases may create conflicts that will delay the promotion of an article. An editor's centrality in an affiliation article network (global network) is supported, but the result for average editor centrality in the global network does not support our hypothesis. A possible explanation for this could be the diffusion of multiple knowledge bases and writing skills, norms and the external cohesion among the focal article editors with other article editor networks, which Carte and Chidambaram (2004) saw as having a curvilinear relationship with efficiency. Therefore, the editing process starts with elements negatively affecting the efficiency. However, later in the editing process, when the editors socialize and understand each other's edits and content, the efficiency improves. Also, this may be due to the nature of the article editing process, which takes the shape of a team structure where the editors take time to socialize, thus understanding and creating a shared norm of editing that promotes the content of the article. Communication in Wikipedia editing starts slowly, but the pace picks up in the later stages of editing, neutralizing the negative effect on the article promotion. This idea is supported by the work of Easley et al. (2003), who found a curvilinear relationship for open

collaboration.

This study has academic and managerial implications. This study contributes to the literature on network position and open collaboration. Key network position members can help communicate relevant information to open collaboration communities. Social collaboration content platforms like Wikipedia can identify editors with a central position to further harness the Wikipedia article editing process. Editors who are central in the content collaboration can continue to support the edits of others to make edits precise, effective, efficient and valuable. Based on the findings from Hypothesis 1, articles that are of high interest to the members of an organization can be utilized for imparting experience and knowledge on members of the organization. An online collaboration platform can use the centrality of the editors to distinguish ego boosters from valuable contributors, as ego boosters try to promote themselves in the community.

For centrality measures from global editor network, editors who are central in the affiliation editor network have no significant effect on the collaboration efficiency. Even though there are many interactions among editors in many articles, it did not delay the promotion to a featured article. Increasing knowledge resources and communicating with other editors are essential to be a featured article and the coordination costs among the editors are not so significant to the duration to be a featured article. However, articles which are central in the affiliation article network have adverse effects on the efficiency as shown in <Table 2> and <Table 3>. If the editors of an article participated in several articles, it has adverse effects on the duration. It may be related to the allocation of the editing time to a specific article. Editors engaging various articles may have difficulties in concentrating knowledge contribution to the article.

Our results highlight several managerial implications for online collaboration platforms. Local or global network structure and position are core concerns for platform managers. An editor's community network and social structure will affect the success of his or her work. Everyone does not equally distribute knowledge contribution and knowledge access; editors contribute when they share their existing knowledge with the community and access that knowledge when they have a large number of direct ties and occupy a central position among those ties. Similarly, editors who work on different articles will have the necessary experience, knowledge and diverse skills to enhance content contribution as well as help in stabilizing the social norms of editing to avoid conflicts and editing wars. Managers of established platforms should encourage their contributors to work on diverse online collaboration projects that will boost their knowledge as well as their ability to work with others to improve efficiency and work-related behavior.

This study is not without limitations. For analysis, we removed edits done by anonymous users and bots. Those removed editors may be editors who just voluntarily contribute without considering registering themselves as members of Wikipedia. This may affect our analysis results on creating the networks of editors and articles and finding the centrality measures. We create relationship networks from an editor's edits on the same article to study the effect of editor network position on efficiency. However, we are not able to practically follow the editor's motives for contributing; we encourage future research to focus on different perspectives of the collaborators' behaviors to determine the attitudes of editors in open collaboration. We conduct our research solely on Wikipedia article editing, so additional insights

are necessary for further studies to generalize the results and investigate the cultural aspects of editing behavior.

Despite its limitations, this article makes important contributions. In particular, it provides important empirical evidence on the network position of editors and its effect on efficiency. Some centrality measures of editors negatively affect the efficiency of collaboration, and the centrality of an article among the different pools of editors negatively affects the efficiency of the article. Further, it is important to mention or highlight members who contribute sufficient and efficient working material for their performance appraisal and promotion.

Future research should pursue a more detailed analysis of content collaboration by analyzing the content of Wikipedia featured articles. Studies on individual edits and their effect on the quality of an article would be of high value.

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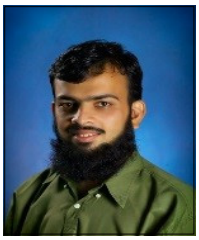

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