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**Helping Wikipedia versus Helping a WikiProject:
Subgroup Dynamics, Member Contribution and Turnover in Online Production Communities**

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ABSTRACT

Many online communities consist of subgroups that co-exist on the same technical platform and serve different interests or purposes. Yet we have limited knowledge of the interplay between subgroups and the large community as a whole and the trade-offs between various outcomes. Does greater contribution at the subgroup level lead to greater or lower contribution to the large community? Are members who belong to multiple subgroups more socially embedded and therefore less likely to leave? Are active contributors more or less likely to leave the community? In this paper, we analyze data from 648 WikiProjects and the archived behaviors of 14,464 member editors to address these questions. Our results reveal two critical trade-offs in managing online production communities. First, a number of factors that increase member contribution such as tenure dissimilarity and past contribution also increase one's likelihood of leaving the community, perhaps due to conflict or feelings of "mission accomplished" or "burnout". Second, individual membership in multiple projects has mixed and largely negative effects. It decreases the amount of work editors contribute to both the individual projects and Wikipedia as a whole. It reduces one's likelihood of leaving individual project yet increases the likelihood of leaving Wikipedia as a whole. The study advances our understanding about the trade-offs between multiple community outcomes and the interplay between subgroups and the large community as a whole.

Keywords: Online community, Wikipedia, contribution, turnover, social media.

¹ John Riedl passed away in July 2013.

1. INTRODUCTION

Online communities play an essential role in today's business and society. Corporate workers join wiki communities to collaborate and share knowledge (Faraj et al. 2011; Majchrzak et al. 2013). Customers join brand communities on Facebook and other social media platforms to advocate for or complain about businesses (Yang et al. 2014). Large crowds of volunteers join open collaboration platforms such as GitHub and Wikipedia to create software or content used by millions of users (Ren et al. forthcoming; von Hippel and von Krogh 2003). After more than a decade of research, we now have a decent body of knowledge on member motivation (Roberts et al. 2006; von Krogh et al. 2003), member identification or commitment (Ren et al. 2007; 2012), the emergence of new leadership styles (Johnson et al. forthcoming), the impact of culture and ideology (Stewart and Gosain 2006), and dynamic evolution of co-production processes (Kane et al. forthcoming) and network structures (Faraj and Johnson 2011; Hahn et al. 2008). While these studies provide valuable insights, there remains much to be learned about online community as a new form of connecting people and organizing work. For instance, many communities consist of subgroups that co-exist on the same technical platform and serve different niche interests or purposes. How do member behaviors and experiences within the subgroups affect their connection with the large community? Does greater contribution at the subgroup level lead to greater or lower contribution to the large community? Are members involved in multiple subgroups more or less likely to stay with the large community? We also have fairly limited knowledge about member turnover. While several studies have examined the driving forces behind continued participation (Johnson 2010; Xia et al. 2011) and the impact of turnover (Ransbotham and Kane 2011), few studies have investigated the factors that cause members to leave an online community. These are the questions we hope to address in this paper.

The interplay between subgroups and the large community is a crucial yet under-explored phenomenon. Online communities are often created and hosted on shared platforms, and subgroups share both membership and the technical infrastructure (Wang et al. 2013). For example, Wikipedia hosts over two thousands projects that are dedicated to various topics; Facebook supports more than 13 million business pages associated with companies, brands, and celebrities; IMDB message boards have hundreds

of discussion boards on different genres, movie and TV talks, movie stars, and trivial matters. These subgroups are created to enable members to interact and collaborate in more intimate settings around their shared interests or goals. In Wikipedia, these subgroups are known as WikiProjects, where members organize to work on Wikipedia articles related to specific topics. The relationship between the subgroups and the large community remains obscure. On one hand, affective connection and commitment to a subgroup (e.g., WikiProject on Internet Culture or a movie discussion sub-forum) can strengthen the web of connections tying the member to the large community and therefore lead to greater commitment to the large community as a whole (e.g., Wikipedia or IMDB) (Ren et al. 2012). On the other hand, subgroups may compete for members' attention, which may overburden and create tension for members belonging to multiple subgroups because they need to decide how much time to allocate to each subgroup (Cummings and Haas 2012; Wang et al. 2013). It is therefore important to understand how member behaviors in subgroups affect their connection to the large community and the degree to which trade-offs manifest between subgroup-level and community-level dynamics.

It is also important to study multiple desirable outcomes. Two most important outcomes are member contribution and retention, both of which are crucial to building and sustaining a vibrant community. A successful online community requires both a "critical mass" of participants (Markus 1987) and a reasonable level of contribution that provides valuable resources to the community (Butler 2001). Current research has focused primarily on how to increase member attachment and contribution (e.g., Ren et al. 2012; Roberts et al. 2006; Wasko and Faraj 2005). In contrast, our knowledge of what causes a member to leave an online community remains limited. Contributors may leave for many different reasons. Some may leave due to outside influences in their lives, such as school, work and family. Others may leave due to lack of fit with within the community or conflict with community members (Kittur et al. 2007). Still others, who are involved in multiple subgroups, may leave due to stress and burnout effects. Few studies have looked into member turnover and what triggers or predicts the staying or leaving of members (see Ransbotham and Kane 2011 for an exception).

In this paper, we investigate member contribution and turnover at both the subgroup level and the large community level in Wikipedia, an online production community. The past decade has observed tremendous growth in the number of online production communities that self-organize on the Internet to accomplish tasks that used to be performed in traditional organizations such as software development and open content. We examine a range of individual attributes and behaviors such as tenure, past contribution, participation in subgroups, and social connections with other contributors in the community and how they affect member contribution and turnover. More specifically, we hope to answer the question of *how individual tenure, past contribution, project involvement, and within- and across-project communication affect contribution and turnover at both the subgroup and community level*. By examining multiple outcomes across both levels, we hope to identify critical trade-offs between contribution and turnover and between subgroup-level and Wikipedia-level outcomes.

We analyze data from 648 WikiProjects and 14,464 individual editors who are members of the projects. Analysis of member contribution and turnover highlights several critical tradeoffs. Comparing the effects of individual attributes on contribution and turnover, we find three factors – tenure dissimilarity, past contribution, and out-project communication – that are positively associated with contribution and also positively associated with one’s likelihood of leaving a project or Wikipedia. These variables have opposite effects on community health by increasing levels of contribution and at the same time making it difficult to retain the active contributors. Comparing outcomes at the WikiProject versus Wikipedia levels, we find two factors – tenure and concurrent projects – that have opposite effects across levels. Tenure is negatively associated with project-level contribution and positively associated with Wikipedia-level contribution. As members gain experiences, they make fewer direct contributions to individual projects and shift to do more work for the large community as a whole. Number of concurrent projects is negatively associated with project-level turnover and positively associated with Wikipedia-level turnover. In other words, belonging to multiple projects reduces one’s likelihood of leaving a WikiProject but increases one’s likelihood of leaving Wikipedia as a whole.

Overall, our study makes three original contributions to the *Information Systems* literature. First, the examination of member contribution and turnover at both subgroup and community levels advances our understanding of subgroup dynamics and the interplay between an online community and its subgroups. We show the potential benefit and risk of institutionalizing a subgroup structure and the unintended negative consequences when community members get overwhelmed by the demand from multiple subgroups. Second, our study is among the first few to investigate the factors that are associated with member turnover. Beyond the common belief in the negative impact of tension and conflict, results from our quantitative and qualitative analysis paint a more sophisticated picture of what may cause members to leave a community such as the feelings of “mission accomplished” or “burnout.” Finally, our study also highlights critical trade-offs between encouraging member contribution and retaining active contributors and provide useful insights to design new generations of tools for community designers to manage the trade-offs and promote sustainable contribution among members.

The rest of our paper is organized as follows. In Section 2 & 3, we review relevant literature on online community, organization science and online volunteerism to ground our research hypotheses. In Section 4, we describe our research setting of Wikipedia and WikiProjects, how we assembled the data set, and our key variables. In Section 5 & 6, we present our main results and discuss their theoretical and practical implications for the design and management of online communities.

2. MEMBER CONTRIBUTION AND TURNOVER IN ONLINE COMMUNITIES

The online community literature provides valuable insights on how a wide variety of factors such as member motivations, identification, and social connections affect levels of contribution. Most studies combine survey and archival data to link self-reported motivations and network positions to member contribution. For instance, Wasko and Faraj (2000; 2005) showed that desire for professional reputation and network centrality are positively associated with volume of contribution in electronic networks of practice. Ma and Agarwal (2007) found that perceived identity verification is strongly related to knowledge contribution. In the context of open source software development, Roberts et al. (2006) found that contribution levels are positively associated with status and negatively associated with use-value

motivations; whereas Lakhani and Wolf (2005) found that enjoyment and fun of solving software problems are the strongest and most persuasive driving force of contribution.

In this paper, we focus on studying two important outcomes to measure the success of an online community: member contribution and turnover. We examine a set of factors that (1) can be derived from archival records and (2) have been linked to individual contribution and turnover in the organization science literature. The goal is to understand their effects on member contribution and turnover at both subgroup and the large community levels so as to develop a cross-level theory about online communities and to provide guidelines that can be implemented with low intrusiveness.

Research on contribution and turnover behaviors in traditional groups and organizations sheds light on studying similar behaviors in online communities (Cotton and Tuttle 1986). At the same time, insights from offline groups may not be readily applicable to online communities. According to Faraj, Jarvenpaa, and Majchrzak (2011), online communities are “a virtual organizational form in which knowledge collaboration can occur in unparalleled scale and scope, in ways not heretofore theorized” (p. 1224). A fundamental difference is their fluidity, which enables a dynamic flow of resources to be integrated and materialized through generative interactions. Following their lead, we identify three specific distinctions between online communities and traditional organizations. First, online communities have low entry and exit barriers. In traditional organizations, employees need to follow established procedures to enter or exit the organization or its subunits and there are often great stakes involved in the exit decision. In contrast, members of most online communities can enter and exit at their free will with less worry for consequences. Second, online communities have little leverage to mandate active contribution. Due to the self-organizing nature of online communities, experienced members or leaders gain lateral authority over the task, not the people (Dahlander and O’Mahony 2011). Members contribute voluntarily and are motivated by both intrinsic and extrinsic incentives (Lakhani and Wolf 2005; Roberts et al. 2006). As a result, factors such as tenure and status may have different effects on individual behaviors in the two settings. Third, compared to traditional organizations, online production communities like Wikipedia often do not offer formal training and socialization programs, both of which

could help new members learn the ropes and form relationships with other members to become more active and involved members. As a result, it is difficult for members to build stronger attachment or connections with the community. These factors combined significantly heightened the challenge that online communities face in encouraging contribution and reducing turnover. In the next section, we first summarize the insights from the literature and then speculate how they generalize to online communities.

3. THEORIES AND HYPOTHESES

3.1 Impact of Tenure on Member Contribution and Turnover

3.1.1. Tenure on contribution. Tenure has been conceptualized and measured as the amount of time that an individual has been part of a group or organization. Organization science literature posits a curvilinear, inverted-U relationship between tenure and employee contribution or productivity (Sturman 2003). When a newcomer first joins an organization, contribution is expected to increase over time as the person acquires skills, accumulates experience, and becomes familiar with organizational routines and policies. After a number of years of effort, individual members are more prone to a burnout effect. The idea of job burnout is based on the potential buildup of stress and exhaustion that may cause workers to decrease contribution (Cordes and Dougherty 1993). Research suggests that burnout especially affects members with longer tenure who have felt frustration on the job (Cordes and Dougherty 1993).

In comparison, there have not been lots of studies that examine the impact of tenure on contribution in online communities. Existing findings paint a somewhat different yet blurred picture. For example, Wasko and Faraj (2005) found a positive link between tenure and member contribution in electronic networks of practice whereas Zhang and Zhu (2011) found a negative link between tenure and contribution in the context of Wikipedia. We suspect the impact is more sophisticated and the real difference is not the amount of contribution, rather the type of contribution. Community vibrancy requires both technical contribution such as coding the software or editing the articles and coordination work such as boundary spanning and resolving conflict. Dahlander and O'Mahony (2011) found that after progressing to lateral authority roles such as board directors, individuals increase their coordination work while reducing their technical contributions to specific projects. A similar scenario in university settings

is after promotion to associate or full professorship, faculty often shift their focus from research activities to administrative service work and they get drafted to help with non-local services at the college or university levels. We thus hypothesize:

H1a. Members with longer tenure tend to contribute less to subgroups but more to the large community as a whole.

3.1.2. Tenure on turnover. Tenure has also been shown to be a strong predictor of turnover and withdrawal behaviors across organizations in different professions (Arnold and Feldman 1982; Authur 1994). Compared to old-timers, newcomers have been consistently shown to be more likely to leave an organization (Griffeth et al. 2000). Similar patterns have been shown in the context of Wikipedia collaboration. Newcomers who lack the experience of doing the work and interacting with other editors may feel frustrated or perceive a lack of fit with individual work groups (Suh et al. 2009). In the context of online open collaboration like Wikipedia, there is often tension and conflict between newcomers who act like content changer and old-timers who act like content retainer. This knowledge change-retain tension typically gets resolved when the content changers get frustrated and cease participation (Kane et al. forthcoming). Due to their lack of experience or status, newcomers' edits are more likely to be reverted and when it happens, newcomers are likely to leave Wikipedia permanently (Halfaker et al. 2011).

H1b. Members with longer tenure are less likely to leave an online community.

3.2 Impact of Tenure Dissimilarity on Member Contribution and Turnover

3.2.1 Tenure dissimilarity on contribution. Another strong predictor of contribution and turnover is interpersonal similarity. Studies of traditional organizations have shown that members who are different from the rest of a group can be discouraged from making substantial contributions due to assumptions that they may be weak performers and because they may have more trouble aligning their interests with the rest of the group (Randel and Jaussi 2003). These arguments hold true for demographic attributes such as age and tenure (Wagner et al. 1984). A newbie in a group that consists of mostly experienced members may feel uncomfortable or inadequately prepared to contribute. Similarly, an experienced member in a

group with mostly newbies may have different goals and ideas that are hard to communicate to the rest of the group. Hence, we expect tenure dissimilarity to be negatively associated with member contribution.

H2a. Members who are dissimilar with the rest of the subgroup tend to contribute less to both the subgroup and the large community as a whole.

3.2.2 Tenure Dissimilarity on Turnover. Tenure dissimilarity also affect turnover (Wagner et al. 1984).

The homophily literature suggests that people tend to interact with others who are similar to them on attributes like age, race, ethnicity, etc. Ties between people will dissolve if there is too much dissimilarity (McPherson et al. 2001), while groups that are more homogeneous, in terms of age and tenure, have fewer members leaving than heterogeneous groups (O'Reilly et al. 1989). We expect that members whose tenure differs more from the rest of the group are more likely to leave.

H2b. Members who are dissimilar with the rest of the subgroup are more likely to leave both the subgroup and the large community as a whole.

3.3 Impact of Past Contribution on Member Contribution and Turnover

In traditional organizations, past performance has been shown to be a reliable predictor of future performance. We posit a similar, positive association between an individual's past and future contribution in online communities. The impact of past contribution on turnover is more complicated. In traditional organizations, poor performers are generally more likely to leave than good performers, which implies that turnover may not be detrimental for the organization (McEvoy and Cascio 1987). Although some past research suggests that high performers can find alternate opportunities and therefore be enticed to leave the organization, more recent studies usually show that poor performers are more prone to voluntary turnover. In addition, these members more often consider other factors, such as job satisfaction, in evaluating whether to remain in the organization (Spencer and Steers 1981). We expect the effects of past contribution on turnover to be more complicated in online communities. On one hand, members with a strong record of past contribution have gained experience and established a high status within the community. As a result, they should be less likely to leave and risk losing their record or status. On the other hand, having contributed a great deal in the past may increase a member's likelihood of leaving the

community if the people feel that they have accomplished their mission or if they feel overwhelmed or burnt out from maintaining a high level of contribution. We believe the former mechanism dominates the latter and therefore we hypothesize:

H3a. Members with a high level of past contribution tend to contribute more.

H3b. Members with a high level of past contribution are less likely to leave.

3.4 Impact of Concurrent Projects on Member Contribution and Turnover

3.4.1 Concurrent projects on contribution. Being involved in multiple groups within a community affects member contribution. Similar to traditional organizations that compete for limited resources (Barron et al. 1994), online groups that are created on the same platform or have similar functions also compete for scarce resources like members' time and effort. Online communities need dedicated members, who put in the most time and effort, in order to survive as a group (Butler 2001). However, from a resource-based view, the amount of time spent on one activity is time that cannot be spent on another (Becker 1965). Sharing members with other subgroups has been linked to difficulty in growing group membership, which suggests that membership overlap puts competitive pressure on subgroups (Wang et al. 2013). Because members have limited time to spend on volunteer work overall, splitting their efforts is likely to cause decreased contribution for individual subgroups. We thus expect members who are involved in multiple projects in Wikipedia to do less work for each project. Reduced contribution for individual subgroups does not necessarily mean reduced contribution for the large community as a whole. Affiliation with multiple subgroups can lead to effective knowledge transfer across the subgroups, and thus make it easy for members to simultaneously contribute to multiple subgroups (Cross and Cummings 2004). Furthermore, in the online context, member participation is socially driven by perception of and interactions with other members (Butler et al. 2007; Farmer and Fedor 1999). Reduced levels of contribution to multiple projects, when aggregated, may exceed total contribution to the large community as a whole. We thus hypothesize:

H4a. Members who are involved in multiple subgroups tend to contribute less to each subgroup but more to the large community as a whole.

3.4.2 Concurrent projects on turnover. Based on the ecological competition view, being involved in multiple projects increases the demand for members' time and effort and, therefore, may increase one's likelihood of turnover. An alternative view on the effects of multiple group membership is job and social embeddedness theory (Mitchell et al. 2001), which suggests that more investment in a job increases the quitting cost, which is negatively correlated with the likelihood of leaving the organization (Mitchell et al. 2001). Someone who is highly embedded in an organization would be less likely to leave. In the context of online communities, members who are affiliated with multiple subgroups are more socially embedded within the large community, which should reduce their likelihood of leaving individual subgroups. Furthermore, in the online context, member participation is socially driven by perception of and interactions with other members (Butler et al. 2007; Farmer and Fedor 1999). The social embeddedness perspective implies that involvement in multiple projects may increase member contribution to Wikipedia as a whole. Similarly, for members who are involved in multiple projects, leaving one project doesn't conclude the person's affiliation with the large community.

H4b. Members who are involved in multiple subgroups are less likely to leave individual subgroups but more likely to leave the large community as a whole.

3.5 Impact of In-Group Communication on Member Contribution and Turnover

Social identity has been shown to be positively correlated with performance measures (Randel and Jaussi 2003). Members who strongly identify with a group are willing to exert greater effort and make more contributions to the group than those who do not identify with the group. This leads to greater social integration of members into the group. As members become more active within a group, they are more likely to be active contributors and display better performance (O'Reilly et al. 1989). Interpersonal relationships or psychological contracts are especially important to increase participation and reduce turnover intentions in not-for-profit volunteer organizations (Farmer and Fedor 1999). Communication with others is an important way for members of online communities to be socially integrated and feel like

an essential part of the group (Haythornthwaite 2009). Social integration and frequent communication with members of one's in-group member is likely to focus members' attention on the group goals and needs, and thus increase their contributions to the group and reduce their likelihood of leaving the group (O'Reilly et al. 1989). We thus hypothesize:

H5a. Members with a high-level of in-group communication tend to contribute more

H5b. Members with a high-level of in-group communication are less likely to leave the subgroup or the large community as a whole.

3.6 Impact of Out-Group Communication on Member Contribution and Turnover

Communication may occur internally within subgroups or externally across subgroups within a large community. Internal and external communication may have different effects on individual behavior. External connections have been shown to affect contribution and turnover differently in traditional organizations. On one hand, an individual's connections with external groups have been shown to improve contribution due to access to novel and relevant information (Cross and Cummings 2004). On the other hand, social networks research has shown that employees or community members who are on the outskirts of groups and have strong external connections are more likely to leave (McPherson et al. 1992). When members have many ties or frequent communication with those outside of a group, they are more likely to be pulled away from the focal group. Increased communication and socialization outside of a group is therefore likely to increase both individual contribution and turnover.

H6a. Members with a high-level of out-group communication tend to contribute more.

H6b. Members with a high-level of out-group communication are more likely to leave the subgroup and the community as a whole.

4. METHODS

4.1 Research Setting

Our research setting is Wikipedia and WikiProjects. Wikipedia is a free online encyclopedia that anyone can edit. An edit is simply a revision, large or small, to any article, talk, or user page. If users perform edits, they may also choose whether or not to register for a user account. Those who have accounts may

then interact with other registered users, or editors, to coordinate work and discuss articles. Each article page has an associated talk page enabling editors to collaborate while working on the article. A WikiProject is defined as “a group of contributors who want to work together as a team to improve Wikipedia. These groups often focus on a specific topic area (for example, women’s history), a specific location or a specific kind of task (for example, checking newly created pages)²”. Since 2002, more than 20,000 Wikipedia editors have joined over 2,000 projects. WikiProjects provide a way to organize editors with the goal of improving a specific subset of articles in Wikipedia. Members may choose to join or leave a project by adding or removing their names on the project’s member list. The main page of a WikiProject typically includes a brief description of the project and its scope, a list of project members, guidelines, and tasks that require member contribution. We chose to study WikiProjects because they are subgroups within the Wikipedia community and have clearly defined goals and boundaries, which make it feasible to assess contribution and turnover at both the subgroup and the large community level.

[Insert Figure 1 about Here]

4.2 Data and Variables

The dataset we use in this study is extracted from the January 2008 dump of the English Wikipedia, which includes the full text of all pages and their complete edit histories from the creation of Wikipedia to the end of 2007. To gather information about projects and their members, we traversed the main directory page of WikiProjects and included all projects that are topical (thus excluding projects such as WikiProject Citation Cleanup). We also excluded projects that never grew to have at least three members (the minimum size of a group), projects that do not have a member list to track membership, and projects whose scopes could not be estimated using categories. Our final data set has 648 WikiProjects and 14,464 individual editors who are or have been members of these projects. We determined each WikiProject’s membership and scope following the approach in Chen et al. (2010). We used historical edits of a project’s member list to identify members of each WikiProject. We considered an editor to have joined a

² <http://en.wikipedia.org/wiki/Wikipedia:WikiProject>

project when her username appeared on the member list and to have left when her username was removed or contribution stopped. To determine the scope of a WikiProject, we first found the Wikipedia category that matched the title (like category *Computer science* for WikiProject *Computer science*). We then traversed all subcategories of the matched category down to the 4th level and considered all articles in those categories to be within the scope of the project (see [citation hidden for review] for more detail).

We constructed a longitudinal dataset. Each observation records the characteristics and activities of an individual editor as a member of a project for each quarter in that project's lifespan. Within each project, each quarter is a 90-day period in a project's lifespan, with the first quarter beginning immediately after its creation date. Within each quarter, every editor who was a member of the project in that quarter was measured once for that project. The level of the analysis is therefore *project individual quarter*, with quarters nested within individuals and individuals nested within projects. For any given WikiProject, the first quarter is the first 90-day period following its date of creation. If the project had 10 members in this quarter, the dataset would have 10 observations for the project during this quarter, with each observation measuring the activity of one editor within the project. In total we had 85,105 project individual quarters in the dataset.

4.3 Dependent Variables

In traditional organizations, individual performance can be measured as the quantity of work output, such as the number of papers and reports produced in a research lab. In Wikipedia, number of edits is a common measure of member contribution (Kittur and Kraut 2008; 2010; Kittur et al. 2007; Suh et al. 2009). In traditional organizations, disenchanted employees may engage in behaviors such as psychological withdrawal, lateness, absenteeism, and turnover (Beehr and Gupta 1978). In Wikipedia, editors may declare exit or simply cease to contribute to a project or Wikipedia as a whole.

Project-Level Contribution: We measured an editor's project-level contribution as the number of edits performed by the editor on articles *within the scope of the WikiProject* during the current quarter.

Project-Level Turnover: We measured an editor's project-level turnover as a binary variable, i.e. either 1 or 0. The variable is 1 if and only if the editor was an active member of the project in the current quarter,

but removed her username from the project member list or stopped contributing within the scope of the project by the end of the next quarter³. We considered a member to be active if the person had at least one edit during that quarter to any of the following: an article within the project scope, the talk page of such an article, any project organization page, or the user pages or user talk pages of another project member.

Wikipedia-Level Contribution: We measured an editor’s Wikipedia-level contribution as the number of edits performed by the editor on *any and all Wikipedia articles* during the current quarter.

Wikipedia-Level Turnover: We measured an editor’s Wikipedia-level turnover as a binary variable, i.e. either 1 or 0. The variable is 1 if and only if the editor had performed at least one edit in Wikipedia during the current quarter but made no edits in Wikipedia in the subsequent quarter.

4.4 Independent Variables

Tenure: We measured an editor’s tenure by how long the editor had been a member of Wikipedia, that is, the number of days elapsed from a member’s first edit in Wikipedia to the end of a quarter.

Tenure Dissimilarity: We measured an editor’s tenure dissimilarity from the rest of the project members using Euclidian Distance as follows (Wagner et al. 1984):

$$\sqrt{\frac{\sum_{j=1}^n (S_i - S_j)^2}{n}}$$

where S_i is tenure for the editor in question, S_j is the tenure of the j -th member in the project, and n is the total number of members currently in the project.

Past Contribution: We measured an editor’s past contribution as the total number of edits performed by the editor on articles within the scope of the WikiProject before the current quarter.

Concurrent Projects: We measured an editor’s concurrent projects by the total number of projects of which the editor is currently listed as a member. A higher number means that the editor is involved in more projects at the same time.

³ 11% of editors returned one or more times after leaving, with a majority returning after one inactive period. Excluding these editors from the analysis did not significantly affect our results. In the analysis below we consider only the last and final instance of turnover for each editor.

In-Project Communication: We measured an editor's in-project communication by the number of edits that other members of the project have made to the editor's user page and user talk page. We only counted edits by others on the editor's pages, not the editor's own edits, for two reasons. First, it is easier to track one user page than two. Second, strong ties tend to be reciprocal, so the amount of inbound communication to an editor should be a good measure of how socially integrated the editor is.

Out-Project Communication: We measured an editor's out-project communication by the number of edits that nonmembers of the project have made to the editor's user page and user talk page.

4.5 Control Variables

Quarter Index: The index of time within the project was measured in quarters (90-day periods), starting with quarter 0 from the moment the project is created until the last full quarter before the end of 2007.

Project Scope: Measured as the number of articles falling under the project scope. Project scope was determined using the same approach as Chen et al. (2010).

Project Size: Measured as the number of project members during the current quarter.

5. RESULTS

Table 1 shows the descriptive statistics and correlations of the key variables. Some variables such as project scope and past contribution are highly skewed to the right so we performed base-2 logarithmic transformations for normality considerations. Because our data is nested by nature, we analyzed the data using Hierarchical Linear Models (HLM) (Bryk and Raudenbush 1992), with member contribution and turnover as the dependent variables and project and individual characteristics as the independent variables. HLM is an advanced form of linear regression that allows us to examine the effects of independent variables on dependent variables while taking into account potential correlations across observations that are nested within a high-level entity (e.g., individuals nested within projects). Our dataset is cross-nested between projects and individuals, meaning an editor can belong to multiple projects. Thus, we ran the analysis using the lmer function in R. We standardized all independent

variables for ease of comparing coefficients across variables. We estimated our HLM models using maximum likelihood estimation, random intercepts, and unstructured covariance structure.

[Insert Table 1 about Here]

Table 2 shows our main results. The first two columns show the effects of project and individual characteristics on project-level contribution and turnover, and the second two columns show the effects on Wikipedia-level contribution and turnover. For each dependent variable, we ran two models: the base model with the intercept and quarter as predictors, and the complete model with two project level variables and six member level variables. Due to the large size of our data set, we examined Bayesian Information Criterion (BIC) to assess model fit. BIC punishes models with a large sample size and a large number of parameters (Burnham and Anderson 2004). We included BIC and deviance between the complete model and the base model in Table 2. In all analyses, the deviance is greater than 10, meaning the complete model fits the data better than the base model.

[Insert Table 2 about Here]

H1a posits a negative relationship between tenure and project-level contribution and a positive relationship between tenure and Wikipedia-level contribution. H1b posits a negative relationship between tenure and turnover at both levels. Our results supported both hypotheses. Tenure was negatively associated with project-level contribution ($-0.165, p < .01$) and positively associated with Wikipedia-level contribution ($0.024, p < .05$). Compared to newcomers, editors with longer tenure contributed less to individual projects but more to Wikipedia as a whole. They were also less likely to leave both individual projects and Wikipedia as a whole ($p < .01$), which supported H1b.

H2a posits a negative relationship between tenure dissimilarity and contribution and H2b posits a positive relationship between tenure dissimilarity and turnover. Our results supported H2b but not H2a. Tenure dissimilarity was positively associated with contribution at both levels ($0.085, p < .01$ for project and $0.029, p < .05$ for Wikipedia) and positively associated with turnover at both levels ($0.108, p < .01$ for project and $0.079, p < .01$ for Wikipedia). Members whose tenure differed from the rest of their project

contributed more edits than those with similar tenure and were more likely to leave both the project and Wikipedia as a whole.

H3a posits a positive relationship between past contribution and current contribution and a negative relationship between past contribution and turnover. Our results supported H3a but not H3b. Members who had contributed more edits in the past continued contributing more to both their local project (0.596, $p < .01$) and Wikipedia (0.113, $p < .01$). Meanwhile, they were also more likely to leave the project (0.362, $p < .01$) or Wikipedia as a whole (0.133, $p < .01$).

H4a posits a negative relationship between concurrent projects and project-level contribution and a positive relationship between concurrent projects and Wikipedia-level contribution. H4b posits a negative relationship between concurrent projects and project-level turnover and a positive relationship between concurrent projects and Wikipedia-level turnover. Our results provided mixed support to both hypotheses. Consistent with H4a, members who belonged to more projects contributed less to individual projects than members who belonged to fewer projects (-0.287, $p < .01$). Contrary to H4a, members who belonged to more projects also contributed less, not more, to Wikipedia (-0.116, $p < .01$). Consistent with H4b, members who belonged to more projects were less likely to leave any individual project (0.108, $p < .01$), but contrary to H4b, they were more likely to leave Wikipedia as a whole (0.034, $p < .01$).

H5a posits a positive relationship between in-project communication and contribution. H5b posits a negative relationship between in-project communication and turnover. Our results supported the hypotheses. Members who communicated more with other project members contributed more edits than those who engaged in less communication (0.611, $p < .01$ for project and 0.29, $p < .01$ for Wikipedia) and they were also less likely to leave (-0.042, $p < .01$ for project and -0.047, $p < .01$ for Wikipedia).

H6a posits a positive relationship between out-project communication and contribution at both levels. H6b posits a positive relationship between out-project communication and turnover at both levels. Our results supported the hypotheses. Members who communicated more with editors outside of the project contributed more, not less, than those who engaged in less out-project communication and this was true for both project-level (1.006, $p < .01$) and Wikipedia level contribution (2.39, $p < .01$). They

were, however, more likely to leave both the local project (0.35, $p < .01$) and Wikipedia as a whole (0.188, $p < .01$). The impact on Wikipedia-level contribution was greater than the impact at the project level whereas the impact on project-level turnover was greater than the impact at the Wikipedia level.

There are some interesting effects of the control variables. In general, as projects aged, their members contributed less and were more likely to leave. In projects with a larger scope, their members tended to contribute more and were less likely to leave Wikipedia than members of projects with a smaller scope. Members of projects with more total editors tended to contribute less to the project but more to Wikipedia as a whole and they were more likely to leave the projects.

6. GENERAL DISCUSSION

We set out to understand two critical trade-offs in online production communities like Wikipedia: the trade-off between various outcomes such as contribution and turnover (whose opposite is retention) and the trade-off between subgroups within a community and the community as a whole. Figure 2 summarizes our main findings. In this section, we discuss the trade-offs revealed in our results, speculate on their underlying processes, and highlight implications for managing online open collaboration. We also include qualitative evidence to supplement and enrich our quantitative evidence.

[Insert Figure 2 about Here]

6.1 Trade-off between Member Contribution and Turnover

A trade-off exists between contribution and turnover when the same factor has opposite effects on them by increasing contribution at the price of increasing one's likelihood of leaving, or vice versa. Our results suggest three such factors as tenure dissimilarity, past contribution, and out-project communication. All three factors are positively associated with contribution but also positively associated with turnover. Members who are dissimilar from the rest of the project and who are actively contributing or communicating with editors outside of one's local project tend to contribute more but were also more likely to leave both their local projects and Wikipedia as a whole. This creates interesting tension and also intervention opportunities for community managers. We gathered some qualitative evidence to help speculate the mechanisms behind these opposite effects. Take past contribution as an example. Contrary

to traditional organizations where poor performers are more likely to leave an organization (McEvoy and Cascio 1987), we find that good performers are more likely to leave or stop contributing. One possible reason is the “mission accomplished” effect, as illustrated in the following quote:

"Having done all I can on the Andorra rugby and womens sevens pages (aside from keep them up to date), I am going to see if I can help with the Shannara project."

Another possible reason is the burnout effect, as illustrated in the following quotes from conversations between active editors who have experienced “wikiburnout” or “wikistress”:

"I am suffering from wikiburnout and chronic Wikistress. [...] I probably won't be able to log in as frequently and contribute as much as I would like."

"On another point; I noticed your wikistress level is high, and your contributions may be dropping. [...] I'd like to add something else; avoid burnout. You are a very active contributor. It is easy for highly active contributors to get caught up in burnout."

A potential intervention is stress management tools to help editors monitor and manage their workload. For example, the meta-wiki of Wikimedia (the organization who hosts Wikipedia) lists tips contributed by editors (<http://meta.wikimedia.org/wiki/Wikistress>) and also suggests that stressed people leave Wikipedia for a short while so they can recover (<http://meta.wikimedia.org/wiki/Wikibreak>). Many active Wikipedia editors created “wikistress meters” on their user pages to indicate their stress levels to fellow editors (<http://en.wikipedia.org/wiki/Template:Wstress3d>). The use of these stress meters may help alleviate the burnout effect of productive editors by increasing awareness of stress levels among editors. However, the effectiveness of such a solution remains limited due to the effort and skills required to create and update the meters. A design opportunity lies in improving the ease of use and functionality of stress awareness tools like stress meters. For instance, software agents can be developed to automatically estimate stress levels from an editor’s recent activity and comparison with historical patterns. Tools like these can be promising for alleviating the stress of productive editors, thus helping to maintain high level of contribution while improving member retention. Similar interventions can be considered to alleviate the challenge of being different from other members and maintain a healthy balance between in-project and out-project communication.

6.2 Trade-off between Subgroups and the Large Community

A trade-off between subgroups and the large community occurs when the same factor improves outcomes at one level while hurting the outcome at the other level. Our results suggest two such factors as tenure and concurrent projects. Members with longer tenure reduce their contribution at the project and shift their focus to do more work at the large community level. Besides quantity, the nature and quality of one's contribution also matters. Hence, the practical implication of such shift is unclear and needs to be investigated in future research. Instead, we will focus on the impact of concurrent projects.

Our results raise concerns about belonging to multiple projects. Membership in multiple projects reduces both one's contribution to local projects and contribution to Wikipedia as a whole. This has wide implications because about 45% of the editors in our data set were involved in more than one project, and about 10% were involved in five or more projects. The only positive effect of multiple group membership seems to be that members who belong to multiple groups are less likely to leave any individual projects (probably because they are deeply embedded or socially locked in) although they are more likely to abandon Wikipedia as a whole than members who only belong to one project. Our qualitative evidence also suggests the detrimental effect is not limited to individual projects. Instead, it may have spilled over to affect other types of work an editor does for Wikipedia. Anecdotal evidence we found on talk page conversations further highlights the challenge for active editors to take on and juggle too many projects and the risk for project leaders to over-draft from the same pool of active editors.

“Goodnes[sic]; I should have abolished this article last month but got too many projects on my plate and forgot.”

“I'm working on too many projects atm. I'm going to be moving slowly here.”

“Ditto. PS. Considered joining us in this fine wikiproject? :)”

“Thanks. I can definitely occasionally lend a hand here and there, but I already am involved in too many projects for the limited time budget I am on.”

The design challenge is how to leverage the benefits of multiple project membership while minimizing its negative impact. Resolving this challenge requires both change to Wikipedia's policies and

guidelines and the development of software tools to improve awareness of editors' activity and commitment across projects. Tools can be developed to share information across projects, such as how many projects an editor has joined, how many edits an editor has made for each of these projects in recent months, etc. Wikistress meters may also be an indication of instances in which editors have been overtaxed by too many projects. We expect such information to provide insights into an editor's workload that may help coordination efforts to avoid competition among projects for member attention. Tools can also be developed to use a combination of signs such as involvement in a large number of projects and sudden or significant drops in recent editing behaviors to generate alerts for editors or project leaders.

6.3 Theoretical Implications

At a high level, many of the insights from social and organizational theories still apply to the online context. Both individual contribution and turnover are affected by factors such as group characteristics, individual attributes like tenure and past performance, and social connections within and across projects. We are able to replicate many patterns discovered in traditional organizations, such as the negative effect of tenure on turnover, the positive effects of internal and external communication on individual productivity and contribution, and the positive effect of external communication on turnover. However, there are several key differences between our findings and predictions from old theories.

One key difference is the negative effect of tenure on individual contribution and the positive effect of past contribution on turnover. Following the organization science literature, we expected old-timers to be more productive and members with low levels of contribution to be more likely to leave. Yet we found the opposite of these effects. The discrepancy can be attributed to the informal and voluntary nature of online communities compared to formalization and bureaucracy in traditional organizations. Members of online communities do not have fixed roles (except those who become administrators) and self-select to take on tasks. The goal of many members may be to find or share information and contribute to a good cause, rather than sticking around and climbing corporate ladders. Therefore, members who have contributed much of their knowledge may either feel a sense of "mission accomplished" or become burnt out and leave or stop contributing.

Another discrepancy between our findings and the organizational literature is the effects of the number of concurrent projects on contribution and turnover. The construct is not unique to the online context (Cummings and Haas 2012) although its manifestation in online communities may be different from the one in traditional organizations. While employees of traditional organizations may work on multiple projects, they are limited in how many they can join, either by their billable hours or managerial oversight. The voluntary nature of online collaboration allows members to join as many projects as they wish, up to or even beyond what their time and effort allow. With greater control and less individual autonomy in choosing projects to join, we expect some differences in the effects of multiple project membership on individual behaviors. For instance, being involved in multiple projects does not necessarily increase one's likelihood of turnover. Instead, individuals may develop social networks with different units within the organization, reducing their likelihood of leaving from these units though they may not have strong bonds with the organization itself. Comparison with the organization science literature reveals a limitation in our measure of contribution. It does not consider the type of work or quality of work. This may help explain the interesting dilemma we found with old-timers – they stay longer with a project but do not contribute as much as newcomers. Because our measure of contribution only considers the quantity of contribution, it is possible that, with more experience, old-timers shift their focus to administrative work or more challenging tasks, which is not reflected in a simple edit count. Examining type and quality of work would be fruitful for future research. Overall, our study confirmed the applicability of social science theories to online communities, while also highlighting the importance of reconsidering and modifying the assumptions and propositions to fit the online context.

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Figure 1: Screenshot of Wikiproject Business

Wikipedia:WikiProject Business

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Points of interest related to [Business](#) on Wikipedia:
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Contents [hide]	
1	Open tasks
1.1	Pages needing attention
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3.3	Participants (assessment division)
4	Participants
5	Inactive

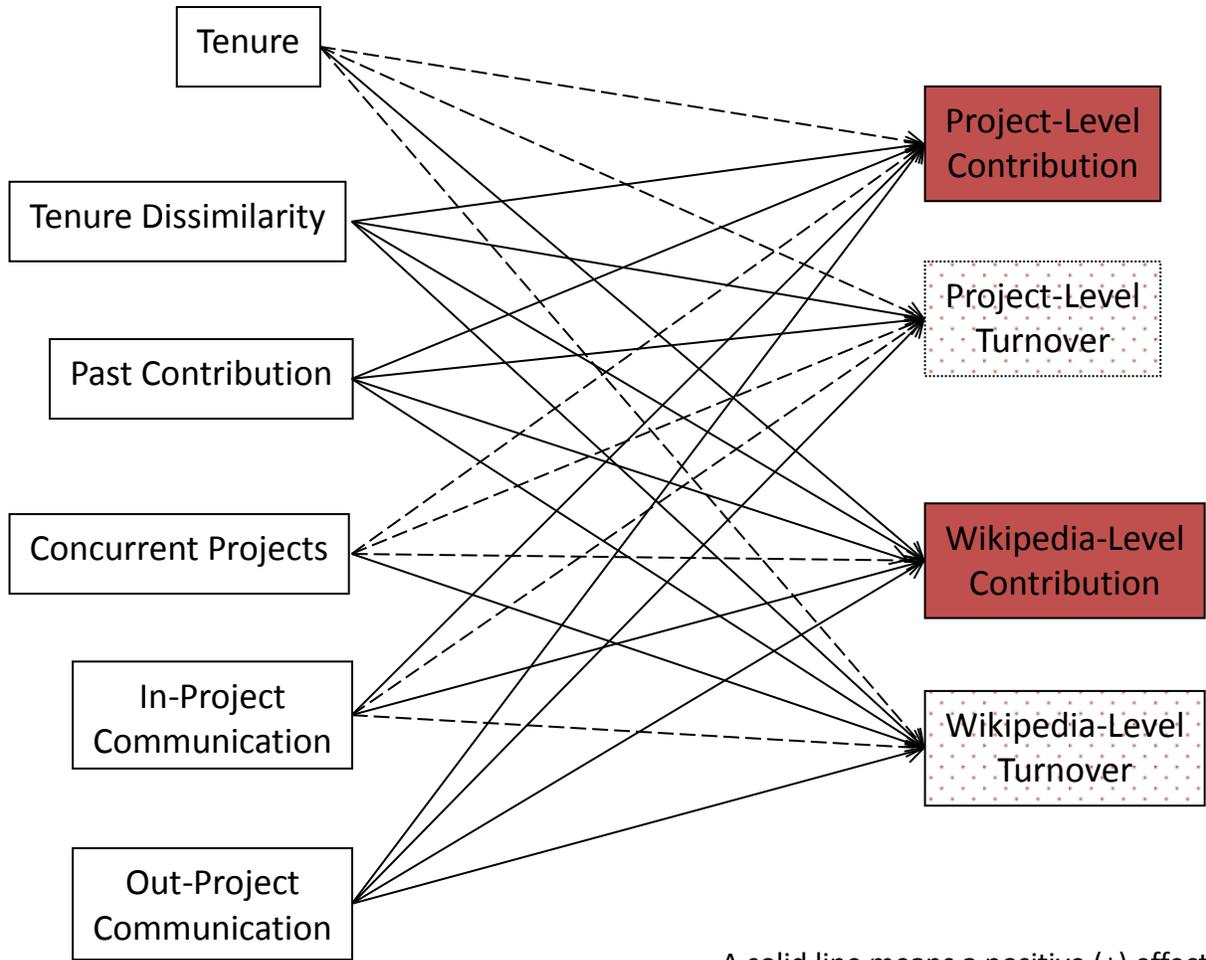
WikiProject Business articles by quality and importance							
Quality	Importance						Total
	Top	High	Mid	Low	NA	???	
★ FA		1	4	9			14
★ FL		1	4	4			9
⊕ GA	2	13	16	53		13	97
B	57	98	226	167	1	63	612
C	35	81	245	310	1	273	945
Start	33	186	1,426	2,436	28	2,481	6,590
Stub	15	58	507	2,331	612	8,728	12,251
List		3	23	70	11	44	151

WikiProject Business



Shortcuts	WP:BUSNS, WP:BUSINESS
Categories	Business, WikiProject Business
Portal	Business and economics portal
Wikimedia Commons	Business
Project banner template	{{WikiProject Business}}
Userbox	{{User Business}}

Figure 2. Summary of Main Findings



A solid line means a positive (+) effect and a dotted line means a negative (-) effect

Table 1. Descriptive Statistics and Correlations of Variables

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Project-level contribution	34.63	162.3												
2. Project-level turnover	0.213	0.409	.02											
3. Wikipedia-level contribution	200.5	656.7	.52	.05										
4. Wikipedia-level turnover	0.262	0.44	.01	.5	-.02									
5. Quarter	5.292	2.864	-.07	.04	-.1	.14								
6. Project size	58.83	49.95	.07	-.01	-.1	.07	.41							
7. Project scope	20681	58493	-.07	.03	.01	.01	.02	.01						
8. Tenure	527.7	341.8	.00	.06	.04	.08	.24	.03	.01					
9. Tenure dissimilarity	405.3	166.8	.00	.06	.01	.08	.21	.00	.05	.48				
10. Past contribution	239.3	832.2	.43	.07	.24	.03	.07	-.02	.08	.14	.05			
11. Concurrent projects	3.253	4.154	.02	.06	.12	.06	.00	-.07	.05	.16	.08	.07		
12. In-project communication	0.964	5.8	.34	.02	.19	-.01	-.06	-.02	-.02	-.02	-.02	.21	.03	
13. Out-project communication	14.44	36.83	.28	.08	.5	-.01	-.11	-.1	.01	.05	.00	.17	.22	.3

Table 2. Predicting Member Contribution and Turnover

Variables	Project-level Contribution	Project-level Turnover	Wikipedia-level Contribution	Wikipedia-level Turnover
Intercept	2.151 ^{**}	- 2.981 ^{**}	5.343 ^{**}	- 5.495 ^{**}
Quarter	- 0.191 ^{**}	0.473 ^{**}	- 0.567 ^{**}	1.236 ^{**}
Project size	- 0.216 ^{**}	0.104 [*]	0.254 ^{**}	- 0.122
Project scope	0.464 ^{**}	- 0.111	0.127 ^{**}	- 0.446 ^{**}
Tenure	-0.165 ^{**}	- 0.129 ^{**}	0.024 [*]	- 0.073 ^{**}
Tenure dissimilarity	0.085 ^{**}	0.108 ^{**}	0.029 [*]	0.079 ^{**}
Past contribution	0.596 ^{**}	0.362 ^{**}	0.113 ^{**}	0.133 ^{**}
Concurrent projects	- 0.287 ^{**}	- 0.061 ^{**}	- 0.116 ^{**}	0.034 ^{**}
In-project communication	0.611 ^{**}	- 0.042 ^{**}	0.29 ^{**}	- 0.047 ^{**}
Out-project communication	1.006 ^{**}	0.35 ^{**}	2.39 ^{**}	0.188 ^{**}
BIC	317209	56144	347630	53816
Deviance	35867 ^{**}	1398 ^{**}	57519 ^{**}	565 ^{**}
N	85105	65393	85105	65393

Note: ^{**} $p < .01$, ^{*} $p < .05$, ⁺ $p < .1$