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Engagement of Information Systems Professionals in Open Source Software Development

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Engagement of Information Systems Professionals in Open Source Software Development

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Abstract

Open source (OS) development of software is becoming increasingly desirable for individuals and organizations alike. Organizations that heavily resisted this new way of developing software are now actively participating in this process. Participation of information systems (IS) professionals in the open source environment has been a focal point in this stream of research in information systems. The dissertation goes beyond participation and examines engagement of IS professionals in the open source environment. The concept of engagement facilitates a more comprehensive understanding of the relationship between a person and a his or her work. The three essays in the dissertation examine three aspects of IS professional's engagement in the open source domain: job engagement, platform engagement, and continued participation. The first essay, using the job characteristics model as a theoretical framework, explores the role of job characteristics in driving job engagement and job satisfaction in open source projects. The second essay examines factors that can influence IS professionals continued contribution to future activities of an open source development platform. Using the social exchange theory, the second essay examines how perceived justice of rewards in OS projects can impact IS professionals' platform engagement and intention to participate in future platform activities. The third essay explores the role of external feedbacks in open source projects. Using the signaling theory, this essay examines how characteristics of external feedback can interact with motivations to influence continued participation intention. The three essays are expected to enrich the information systems literature by providing new insights on various factors that can enhance engagement of IS professionals in the open source domain. The essays also contribute to the IS literature by applying the job characteristics model, social exchange theory, and signaling theory in the context of open source development.

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Introduction

Open source development (OSD) of information systems continues to be a dominant trend that is becoming increasingly popular with individuals and organizations. For instance, Sourceforge, one of the most popular OSD platforms, claims that it has hosted more than 430,000 software projects in its platform and facilitated more than four and half million downloads of open source software in average per day[1]. Linux Foundation, a pioneer in OSD, claims that more than a million information systems (IS) professionals have participated in its open source drive that resulted in an estimated sixteen billion dollars' worth of software projects[2]. Organizations, both private and public, are becoming interested taking advantage of OSD. For instance, Data.gov, a US government-sponsored website that makes thousands of datasets available to the general public, has been using GitHub as an OSD platform for its open source applications. OSD is a new frontier of software development that will require project managers to understand the dynamics of this environment for organizations to utilize its full potentials. Our research attempts to provide new insights for project managers and project management researchers in the new era of open source software development. A cross-sectional design was used to collect primary data. The internal review board approval for the data collection is provided in the appendix. The three essays explore IS professionals' relationships with open source (OS) projects and open source platforms. The first essay explores the role of job characteristics in driving job engagement and job satisfaction in open source projects using the job characteristics model. The second essay examines factors that can influence IS professionals continued contribution to future activities of an open source development platform

[1] https://sourceforge.net/
[2] https://www.linuxfoundation.org/

using the social exchange theory. The third essay explores the role of external feedbacks in open source projects using the signaling theory.

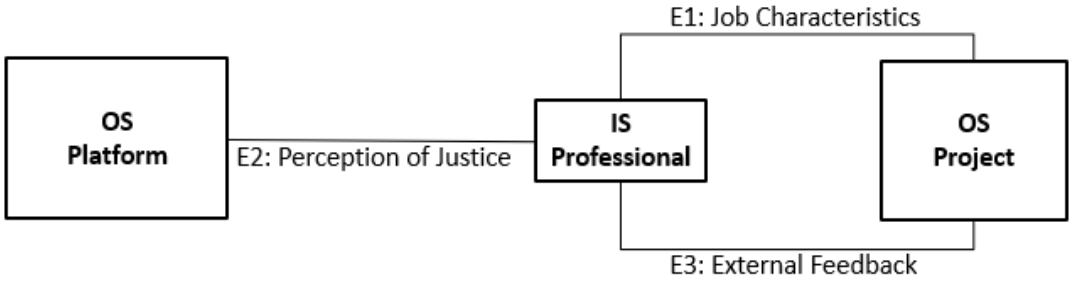

Figure 1: The Relationships Explored in the Three Essays

The figure above depicts the relationships that are explored in the three essays and the topics that are used in the essays to understand these relationships. The rest of the dissertation contains the three individual essays starting with the first essay.

Essay 1

EXAMINING ENGAGEMENT IN OPEN SOURCE SOFTWARE DEVELOPMENT THROUGH THE LENS OF JOB CHARACTERISTICS MODEL

ABSTRACT

Open source development (OSD) of software is becoming increasingly desirable for individuals and organizations alike. Even organizations that heavily resisted this new way of developing software are now actively participating in this process. Participation of developers in the OSD environment has been a focal point of research in the information systems (IS) domain that has examined various reasons developers participate in open source projects. Our study goes beyond participation and looks at engagement of developers in the OSD environment. Using the job characteristics model (JCM) as the theoretical lens, we conducted an exploratory study that examines engagement and job satisfaction of IS professionals working in the OSD environment. This study included responses from 165 IS professionals working in various OSD projects. This study finds that several job characteristics significantly influence the engagement of IS professionals working in OSD. The study also finds that engagement plays a mediating role between job characteristics and job satisfaction. The research enriches the open source literature and extends JCM. The study also provides new insight to organizations and individuals that are currently investing in OSD or planning to do so in the near future.

Keywords: Open source, software development, engagement, job characteristics, job satisfaction, information systems development.

INTRODUCTION

Volunteer participation is at the heart of success of the OSD model. However, it has been found that a lack of voluntary participation affects a large percentage of OSD projects (Fang and

Neufeld 2009). Even after a decade of that finding by Fang and Neufeld (2009), how to increase voluntary participation remains an important question for IS researchers (Ho and Rai 2017). IS researchers have explored various factors that can influence participation of IS professionals in the OSD environment. A stream of literature found that participation in the OSD is an outcome of a combination of intrinsic and extrinsic motivations (Alam and Campbell 2017; Hars and Ou 2002; Hertel et al. 2003). Prior collaboration ties have been found to be one of the significant factors that influence the IS professional's decision to join a new OSD project (Hahn et al. 2008). Besides personal attributes and aspiration, project attributes can also drive participation of IS professionals in the OSD. Project attributes such as quality control and project type have been found to influence continued voluntary participation (Ho and Rai 2017). Participation of IS professionals is crucial in OSD because it is related to performance. Roberts et al. (2006) found that IS professionals' participation is positively related to their performance in OSD software projects. Table 1 below lists a few notable studies that have examined various factors that drive participation (and similar or related constructs) of IS professionals in open source projects.

Table 1: Notable Research on participation in the open source environment

Reference	Independent Variable(s)	Dependent Variable(s)
Alam and Campbell 2017	Intrinsic motivation, extrinsic motivation	Volunteer participation in cultural crowdsourcing work
Bagozzi and Dholakia 2006	Social identity, identification, emotions, attitudes, experience with the platform	Participation intentions
Blanchard and Markus 2004	Feelings of membership and influence, integration and fulfillment of needs and shared emotional connection	The sense of virtual community
Daniel et al. 2018	Ideology, commitment to company, commitment to OSS community	Continued code contribution
Fang and Neufeld 2009	Situated learning, identity construction	Long-term voluntary participation
Faraj and Johnson 2011	Direct reciprocity, indirect reciprocity, preferential attachment	
Faraj et al. 2011	Tension resulting from the fluidity	Participation
Hahn et al. 2008	Cohesion cues and status cues based on the developer's past collaboration	Join
Hann et al. 2004	Social-psychological functions (normative, values, understanding, career concerns, and ego enhancement)	participation
Hars and Ou 2002	Self-determination, altruism, community identification, future rewards, personal need	Participation
Hertel et al. 2003	Valence, instrumentality, self-efficacy, and trust	Participation
Ho and Rai 2017	Quality control, type of project, tenure in the project	Volunteers continued participation intention
Lerner and Tirole 2002	Career concern incentive, ego gratification incentive	Participation
Ma and Agarwal 2007	Perceived identity verification, satisfaction	Knowledge contribution
Maruping et al. 2019	Developer open source values, centrality in communication network, commitment to open source community	Code contribution activity
Nambisan and Baron 2010	The sense of responsibility to community and company, expectations of self-image and expertise enhancement, identification with community and company	Contribution
von Hippel and von Krogh 2003	Private-collective model of innovation (Private rewards)	Contribution

The literature on participation, continued participation, or contribution etc. seems to converge into two overarching themes: one is focused on the individual attributes of the person (e.g., philanthropy, commitment, intrinsic or extrinsic motivation) and the other is focused on the attributes of the projects (e.g., quality control, project type, project size). While research on the first theme are quite large and still expanding, research on the second theme are still sparse. Moreover, the project attributes are related to the projects in general (e.g., quality control in a project is about maintaining control for the whole project). In other words, we are yet to see research work that examines project attributes specific to individuals who are contributing to open source projects, attributes that are related to their roles. We address this gap.

However, we examine engagement, a psychological construct that demonstrates a deep relationship of an individual with his or her work instead of participation, a behavioral construct that is measured by the amount of direct contribution (e.g., number of lines of code or number of bugs reported). Engagement encapsulates the deep relationship between an individual's self and his or her work at physical, emotional, and cognitive level (Rich et al. 2010). The idea of engagement at workplace was first conceptualized as personal engagement and disengagement by Kahn (1990). Since then engagement has been used in the management and organizational behavior as the construct that helps explain the relationship between a person and his or her role at work (Saks and Gruman 2014). Table 2 lists a few notable studies that examined engagement in various contexts. All these studies document that engagement tend to drive many individual (performance, organizational citizenship behavior, job satisfaction) and organizational outcomes (profitability, business unit outcomes, turnover). As more individuals and organizations become more interested in open source software development, we think it is important to study this construct in the OS domain. Even though engagement has been called various names such as

employee engagement (Anthony-McMann et al. 2017), work engagement (Halbesleben 2010), job engagement (Rich et al. 2010; Saks 2006), all of these terms refers to the relationship between a person and his or her role at work. We argue that engagement allows us to capture a more comprehensive understanding of the relationship (physical, emotional, and cognitive) between an OSD project and the role(s) played the IS professional working on the project, hence, it would be more useful construct in the open source context than participation.

Table 2: Brief Overview of the Engagement Literature

Reference	Dimensions Studied	Relationships Tested	Theory Used
Anthony-McMann et al. 2017	Physical, Emotional, Cognitive, Social, affective, intellectual	Burnout, Stress	Conservation of Resources theory
Halbesleben 2006	Disengagement (burnout)	Social Support	Conservation of Resources
Harter et al. 2002	Employee Engagement	Business unit outcomes	N/A
Harter et al. 2013	Employee Engagement	Profitability	N/A
Kahn 1990	Personal Engagement and Personal Disengagement	Psychological Meaningfulness, safety, and availability	Theory of personal engagement at work. Extended Person-in-role research with personal engagement and disengagement (started with the work of Goffman 1961)
Kahn 1992	Personal engagement	Work elements, elements of social systems	Theory of engagement Job Characteristics Theory
Rich et al. 2010	Physical, Emotional, Cognitive	Performance	Khan' Theory
Saks 2006	Job and Organization	Job Satisfaction, OCB, Turnover, Organizational commitment	Social Exchange Theory
Schaufeli et al. 2002	Vigor, dedication, absorption	Burnout	Khan's theory
Shuck et al. 2011	Employee Engagement	Job Satisfaction	Khan's theory
Soane et al. 2012	Intellectual, social, affective	OCB, Performance, Turnover Intentions	Khan's Theory

We use the job characteristics model (JCM: Hackman and Oldham 1980) as the overarching theoretical framework to study the antecedents and consequences of engagement of IS professionals in the OSD environment. One of the most useful qualities of JCM is that it does not include any payment factor in the model and therefore presents a readily available theoretical lens that can be used in the OSD environment where IS professionals are primarily volunteers. Building on the JCM, we develop a model that examines how job characteristics, along with other OSD relevant factors, influence engagement of IS professionals in the OSD environment. Our model also examines the mediating role of engagement between job characteristics and job satisfaction of these IS professionals. We used a survey study design to ask IS professionals working on various types of OSD projects that serves educational, gaming, communication and several other industries. The host platforms for the projects included but not limited to well-known OSD platform such as GitHub, Sourceforge, and Linux. A total of 165 IS professionals' responses were included in our final analysis. The respondents' roles ranged from peripheral developer to core member. The results are supportive of the central assertion that job characteristics play an important role in driving the level of engagement of IS professionals in the OSD environment.

Our study makes several contributions to the existing literature. By studying engagement in the OSD environment, our study contributes to both open source and engagement literature. The engagement framework helps us understand IS professional's relationship to his or her OSD project in a more meaningful way. The study contributes to the engagement literature by applying this framework in the open source context. Job characteristics model (JCM) has been used as a theoretical lens to understand various facets of an IS professional's job and to examine how these characteristics influence work outcomes in the proprietary software development

(PSD) environment (e.g., Tripp et al. 2016; Morris and Venkatesh 2010). In addition to applying the JCM in the OSD context, our study extends JCM by positioning engagement as a mediator in the nomological network between job characteristics and job satisfaction. Finally, there is a tremendous interest in organizations to explore and utilize the OSD for software development (Ho and Rai 2017). Understanding the role of job characteristics in the OSD should also help IS project managers designing projects that can leverage such knowledge and ultimately help numerous organizations and individuals who have already invested or planning to invest in the OSD.

THEORY

We design this section in three subsections; we start by defining the constructs. The core sets of the constructs in our research model include job engagement, job characteristics, and job satisfaction. Then we propose our research model and conclude with our justifications of the hypotheses in our research model.

Construct Definitions

Even though traditionally *job* has been associated with paid positions, both dictionaries and scholarly literature demonstrate that the concept of *job* covers more than traditional paid participation and has the potential to be used in the OSD environment where a vast majority of participants are not directly paid. First, we explore the dictionary perspective on job. Job has been defined by Merriam-Webster[3] dictionary in three ways: a) a regular remunerative position b) a specific duty, role, or function and c) something has to be done, a task. While the first definition resembles to a paid job, the remaining two definitions provide a more generalized definition that can be applied beyond the paradigm of paid job into the world of open source

[3] https://www.merriam-webster.com/dictionary/job

development where a vast majority of developers give their time, talent, and energy to complete projects that do not provide any direct and/or immediate financial payment. The Business Dictionary[4] also provides a similar definition that "from a wider perspective, a job is synonymous with a role and includes the physical and social aspects of a work environment. Often, individuals identify themselves with their job or role (foreman, supervisor, engineer etc.) and derive motivation from its uniqueness or usefulness." Second, *job* has been studied in the scholarly literature using various aspects of it; some called them dimensions, other referred to them as attributes. These studies have been largely focused on enhancing job designing, job experience or performance. Even though these studies have been conducted in the context of paid jobs, the focus have been mostly on the non-financial aspects of job. For instance, Turner and Lawrence (1965) studied six attributes of job – variety, autonomy, required interaction, optional interaction, knowledge and skill required, and responsibility. Hackman and Lawler (1971) used variety, autonomy, task identity, and feedback as the "core dimensions" that describe a job. None of these attributes or dimensions is directly related to payment.

Hence, based on the understanding of job that hinges on the role and task of a person and not based on financial payment, we argue that when an IS professional uses his or her capabilities to perform a task or group of tasks that fulfills her role(s) (e.g., developer, tester) in an open source IS development project, his participation in the project constitutes as a *job* regardless of whether a payment is made or not. In other words, a job in the open source development environment refers to a task or a group of tasks in an open source project associated with the participant's role(s) in the project. *Job engagement* in open source development refers to the physical, cognitive, and emotional investment made by a participant in performing the task or

[4] http://www.businessdictionary.com/definition/job.html

group of tasks in the open source project that serves his or her role in the project. Our definition is guided by Kahn (1990) who referred to engagement as "the harnessing of organization members' selves to their work roles; in engagement, people employ and express themselves physically, cognitively, and emotionally during role performances" (p.694).

We adapt the definitions of the five JCM constructs from Hackman and Oldham (1980) as the original source but also guided by Morris and Venkatesh (2010) due to their application of the JCM constructs in the IS context. *Task significance* is defined as the perception of the IS professional as to how significant the open source project is in relations to society or organization. *Task identity* is defined as the portion of the open source project the IS professional has been involved with. *Skill variety* is defined as the variation in skillset that is utilized by the IS professional to accomplish his or her task in the open source project. *Autonomy* is defined as the degree of freedom enjoyed by the IS professional in deciding how to accomplish his or her task in the open source project. *Feedback* is defined as the extent of information provided by the open source project itself that help the IS professional to determine the quality of his or her input in the project.

Job satisfaction is a well-established construct in the psychological, organizational behavior, and IS literature. We adapt our definition from previous IS (Tripp et al. 2016; Morris and Venkatesh 2010) and engagement literature (Rich et al. 2010). *Job satisfaction* in open source development refers to the degree of positive emotional response generated by an IS professional's assessment of the experience gained due his/her role(s) in the open source project.

Research Model

Our research model attempts to achieve two goals. First, we attempt to examine the relationship between job characteristics and engagement in the context of open source software

development. The influence of job characteristics on work outcomes is of great interest to IS and organizational researchers. Appendix A includes few notable studies in the IS literature that used the job characteristics model. Job characteristics have been studied as antecedents to employee engagement in various organizational studies (e.g., Saks 2006; Rich et al. 2010; Christian et al. 2011). However, to the best of our knowledge, no study in the IS literature has so far attempted to study this relationship in the context of open source. Context can change the relationship in various ways (Johns 2006). Johns (2006) defined "context as situational opportunities and constraints that affect the occurrence and meaning of organizational behavior as well as functional relationships between variables. Context can serve as a main effect or interact with personal variables such as a disposition to affect organizational behavior" (p. 386). Open source software development is unique in its approach (voluntary) and economics (the availability of the source code) and have been established to be fundamentally different from traditional organization driven, managed, and resourced software development (Hars and Ou 2002) and therefore represent unique context of IS development. Because open source software development is heavily dependent on IS professionals voluntarily joining projects, we argue that *the job characteristics of a project will play important roles in driving the engagement of those who will take part in the project*.

The direct influence of job characteristics on job satisfaction is well-established in the IS literature (Goldstein and Rockart 1984; Specht 1986; Kaplan and Duchon 1988; Igbaria et al. 1994; Morris and Venkatesh 2010; Bala and Venkatesh 2013). However, engagement has been found to play a mediating role in the relationship between job characteristics and job satisfaction in the non-IS literature (e.g., Saks 2006; Rich et al. 2010). To the best of our knowledge, these relationships have never been studied in the context of open source development. Thus, the

second goal of our research model is to *test the mediating effect of IS professional's engagement in the relationship between job characteristics and job satisfaction* in the open source context. In line with the recent IS studies of JCM (e.g., Tripp et al. 2016; Morris and Venkatesh 2010; Venkatesh et al. 2010), we utilize the JCM proposed by Hackman and Oldham (1980). Figure 1 depicts our proposed research model.

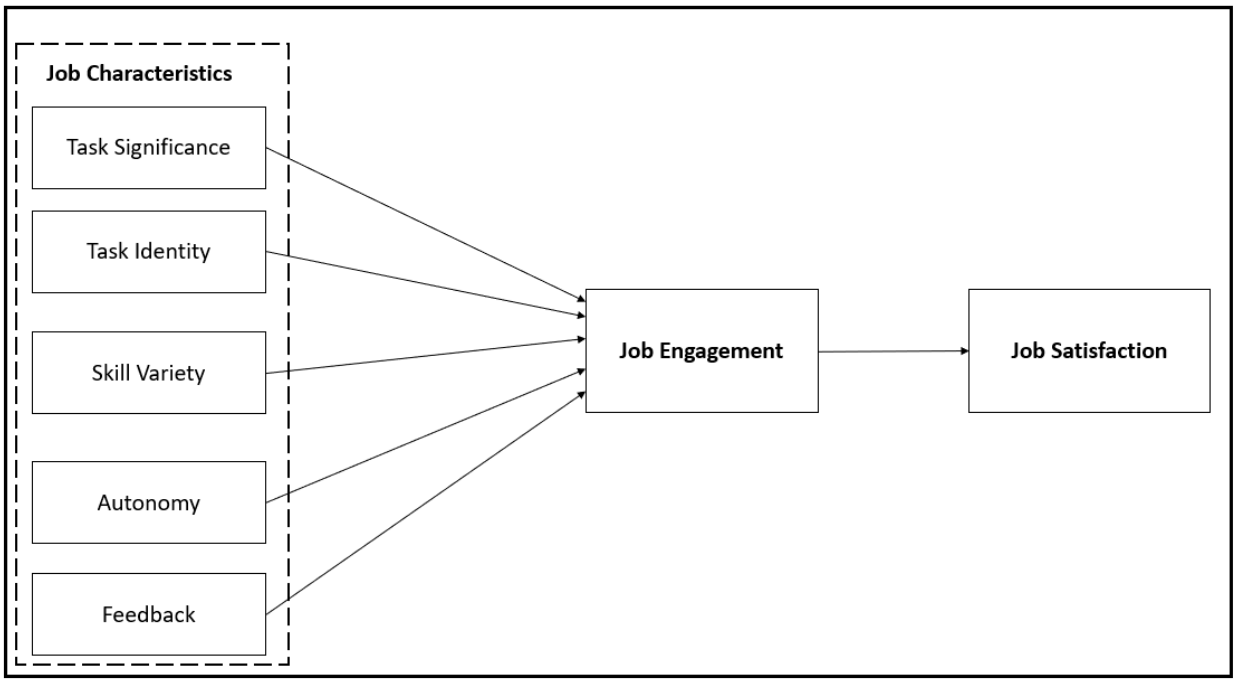

Figure 1: Research Model

Hypotheses Development

Out of the five job characteristics that are part of JCM, task significance and task identity are the most directly related to the specific nature of the job (Morris and Venkatesh 2010). These job characteristics include two very important perceptions of someone's job – how important the task is and how much contribution an individual can make (Hackman and Oldham 1974). Altruism has been found to be one of the most significant motivation for engaging in the OSD environment (e.g., von Krogh et al. 2012; Rafaeli and Ariel 2008; Hars and Ou 2002). IS professionals contribute to software development in OSD because they think they are helping

others by donating their time and energy (Hars and Ou 2002). We argue that, if altruism is the motivation for participation in OSD, a reasonable person would choose to engage more in a software project that s/he thinks will have more impact on others than another project with perceived to have less significance. Identification has been noted as another important motivation for IS professional's participation in the OSD and a cornerstone of the open source movement (Hars and Ou 2002; Blanchard and Markus 2004; Bagozzi and Dholakia 2006). In general, researchers have found such identification to be social in nature where IS professionals identify with the open source movement and tend to engage in open source projects to support this movement (Bagozzi and Dholakia 2006). In this case, IS professionals will perceive that their contribution is part of larger movement. Researchers have also found that identification to a specific OSD platform or project can be an important motivation for participation. For instance, Hertel et al. (2003) found that specific identification as a Linux developer or with a subsystem was the most significant factor that influenced participant's engagement. Hence, we argue that task identity will have a positive influence on IS professional's job enagement in the open source environment. Based on the above justification that task significance and task identity are important factor for job engagement of IS professional's in the open source environment, we hypothesize that

H1a: Task significance associated with the role(s) of an IS professional in an open source project will positively influence his or her job engagement.

H1b: Task identity associated with the role(s) of an IS professional in an open source project will positively influence his or her job engagement.

OSD projects are quite diverse and provide a unique opportunity for IS professionals to develop and demonstrate their skillset. Information systems is a dynamic field with frequent

introduction of new technology, algorithms, and programming languages. Therefore, learning new skills is crucial for IS professionals to survive and enrich their careers in this fast-changing technology field. Researchers have found that open source projects can help IS professionals to learn new skills and has been an important motivation for their participation in OSD (Hars and Ou 2002; von Krogh et al. 2012). OSD does not only provide an IS professional the ability to pick a project in an area of expertise interesting and beneficial to the person but also provides a starting point for new entry as previous codes are readily available to newcomer for review. OSD also provides opportunity to showcase an IS professional's skillset to potential clients and has been documented as one of the prime motivations for participation in OSD projects (Hars and Ou 2002; Lerner and Tirole 2002; von Hippel and von Krogh 2003). Since many organizations are becoming interested in the OSD platform as suggested by contemporary research (Ho and Rai 2017) and OSD provides opportunities to learn and display new skills, we argue that skill variety will play a more important role in engaging an IS professional in the OSD environment. Hence, we hypothesize that

H1c: Higher degree of skill variety required in an open source project will lead to higher level of job engagement of the IS professional working in the open source project.

Autonomy is the cornerstone of OSD development. Unlike the PSD environment, where people have some form of contractual obligation and possibly have serious career ramification on abandoning a project, IS professionals are not bound by any contractual obligation in the OSD environment. Therefore, IS professionals in the OSD enjoys quite higher degree of autonomy because they can always leave the project if they are unable to perform the task in their own way. Researchers have found that 80% of open source project are terminated because participant left the projects during development (Fang and Nuefeld 2009), a finding that motivated Ho and Rai

(2017) to examine factors that affect "volunteers' continued participation intention." Since IS professionals expects a high level of autonomy in open source projects to begin with, we argue that an IS professional may simply leave the project if they do not enjoy a high level of autonomy; but a high level of autonomy will not make any difference in his or her level of job engagement. Hence, we hypothesize that,

H1d: The level of autonomy in an open source project will not significantly impact the job engagement of the IS professional working in the project.

Organizations are built on structures that are designed to provide feedback through various types of coordination to facilitate the most efficient production, and information systems are built to help coordination (Gurbaxani and Whang 1991). Feedback in the proprietary environment is much more structured than it is in the OSD environment and driven by others than the task itself. On the other hand, feedback from others in the OSD is much less organized and formal. For instance, code acceptance by project administration is used as an indicator of performance in OSD (Ho and Rai 2017; Roberts et al. 2006; Hertel et al. 2003). Another form of feedback could be users' rating and comments. However, the most important feedback in the OSD is the enhancement of the code itself. Developers in OSD take the initiative to enhance an existing code, sometimes for their own use, and relies on the performance of the project to determine their own success. In other words, feedback, as it is defined in the job characteristics model, is very important to a contributor in the open source environment. Hence, we hypothesize that

H1e: Higher level of feedback from an open source project will lead to higher level of job engagement of the IS professional contributing to the project.

The mediating role of engagement

There are three reasons which leads us to argue that job engagement plays a mediating role between job characteristics and job satisfaction. First, job characteristics have been found as an antecedent to employee engagement in social science studies (e.g. Christian et al. 2011; Crawford et al. 2010; Saks 2006). Christian et al. (2011) argues that when job characteristics allow for a person to invest more "energy and personal resources" s/he will be more engaged in that job. The findings of Crawford et al. (2010) echoes a similar conclusion that some job characteristics (autonomy, feedback, variety) are positively related to engagement. "According to Kahn (1990, 1992), psychological meaningfulness can be achieved from task characteristics that provide challenging work, variety, allow the use of different skills, personal discretion, and the opportunity to make important contributions" (Saks 2006, p.604). In other words, Saks (2006) argues that positive job characteristics tend to impact job engagement more positively. Second, engagement tend to impact work outcomes positively. Kahn (1992) proposed that both individual and organizational outcomes will be influenced by employee engagement which is a reasonable conclusion given the emotional state an engaged employee reaches. Subsequent research found engagement to influence various individual outcomes including job satisfaction. Third, engagement has been identified to play a mediating role in between many work conditions and outcomes (Maslach et al. 2001; Schaufeli and Bakker 2004; Hakanen et al. 2006; Saks 2006; Rich et al. 2010; Christian et al. 2011). Based on the above-mentioned findings in the existing literature we argue that job engagement will play a mediating role. Hence, we hypothesize

H2: IS professional's job engagement will mediate the relationship between job characteristics and job satisfaction in open source project.

RESEARCH METHODOLOGY

Study Design

We conducted our study of job characteristics and engagement using a cross-section survey design. The survey included established measures from the information systems, project management, and engagement literature. The survey was posted in Amazon Mechanical Turk (AMT). While the AMT was used as a marketing tool to reach potential respondents, the survey itself was hosted in the Qualtrics server. AMT directed interested IT professionals to an anonymous link hosted by Qualtrics. Respondents were paid $5 for a fully completed survey. Each respondent who reached the end of the survey was provided a random seven-digit code that s/he would provide to AMT to receive the payment from AMT. The respondents had four hours to complete the survey. The clock would start at the time when a respondent chose to respond in the AMT system and the clock would end at the time when a respondent provided the random code s/he receive from the Qualtrics survey.

The survey on AMT was designed to be marketed to IS professionals. To ensure that the survey was marketed to the right people, we used the AMT category 'Job Function – Information Technology' as a requirement. We included further screening in the survey in addition to AMT's IT professional category. The screening included the following questions: "Are you an information system or technology professional? Are you currently participating or recent participated in one or more open source development of information systems projects?" The questions also included a highlighted note that "A potential participant of this survey must be an information systems or technology professional who is currently contributing or has contributed in one or more open source software development project(s). Hence, answering NO to this question will terminate the survey." The survey automatically moved to the end for a participant

who answered negatively to any of these questions. If a participant indeed answered 'no' to these questions s/he received a note of appreciation and an explanation to the abrupt termination. The note was as follows: "THANK YOU for your time and effort in completing this survey. We sincerely appreciate your contribution to our research. In case you have reached this point only after the first one or two questions, that means you have answered no to any of the first two questions. As we mentioned in our disclosure, a potential participant must be an information systems or information technology professional who is currently participating or has participated in one or more open source software development project(s). Hence, answering NO to these questions have terminated the survey for you. In any event, we appreciate your interest."

Participants

We received a total of 330 responses. These 330 respondents reached the end of the survey and provided the code to AMT to collect their payments. However, only 165 responses were included in the final analysis in this paper. Reponses were excluded from the final analysis for two reasons: partial answers and lack of useful details. First, the responses that did not include answers for the focal variables (job characteristics, engagement, and job satisfaction) were deemed as incomplete and excluded from the analysis. Most of the responses that were excluded fell into this first category. Second, responses that appeared to provide vague, unrelated, or meaningless answers were deemed as answers that lack useful details. For instance, one response mentioned "music player" as the project description. Another example would be a response that mentioned "A front-end JavaScript framework" as the project description. Since these responses failed to provide a good description of the open source project, we did not think they are reliable enough for out study. Approximately twenty two percent of the respondents were female, and the remaining respondents were male. The highest number of respondents aged

between 31 and 40 years (approximately 46%) followed by respondents who aged between 21 and 30 years (approximately 41%). One respondent did not answer the age group or the gender question. A more detailed demographic data is provided in Table 3. The following table about the demographics indicates that, as per this sample, mostly younger professionals who are early in their career and in their 20s and 30s are involved more heavily in open source development than those who are in their 40s and 50s.

Table 3: Participants' Demographics

Age Group	Female	Male	Total
Below 20 years	0	1	1
Between 21 and 30 years	16	52	68
Between 31 and 40 years	18	57	75
Between 41 and 50 years		16	16
Above 50 years	2	2	4
Total	36	128	164

The respondents had an average of approximately 8 years of experience in development of information systems and approximately 6 years of work experience in open source development of information systems. 48% respondents reported that they contribute to open source project both for free and for payment. However, 31% reported that they only contribute for free while the remaining 21% contribute only for a payment. The projects in our sample included both voluntary projects (106) that did not involve any payments and paid (59) projects. A large majority, approximately 39%, of the projects were initiated by a private individual or a group of individuals. 22% projects were initiated by the platform organization, 22% by a non-profit other than the platform, and the remaining projects were initiated by a for-profit organization. 39 out of the 165 projects were designed for the education, 19 for gaming, 45 for communication, 42 for utilities and the rest did not fall in the four categories listed above. Even though the respondents mentioned various open source platforms they prefer to work with, the top 5 favorite platforms included GitHub, Linux, Kaggle, Sourceforge, and Oracle

BeehiveOnline.

The respondents were involved in a wider variety of open source projects hosted in various OS platforms that are compatible with operating systems such as Linux, windows. The purpose for these projects included but not limited to e-commerce, security enhancement, artificial intelligence, heatmap, internet bot, and crypto currency. Few projects are listed in the Table 4 that were hosted in a variety of open source platforms and compatible with major operating systems, include both free and paid projects, and represent the major sectors – education, gaming, communication, and utilities. The project descriptions are slightly modified to make the description more understandable.

Table 4: Brief Description of few OS Projects included in the Study Sample

Brief project description	**Contribution Type**	**Host Platform**	**Compatible OS**	**Role(s) of the respondent**
Ecommerce functionalities with advanced custom features	Free	GitHub	Linux, Windows	Peripheral Developer
Develop software to meet organization's new privacy standards	Paid	Sourceforge		Active Developer
Speech recognition software to provide gamers the ability to give voice commands to interact with games.	Free	GitHub	Linux	Active Developer, Documenter
Facilitate sharing study materials for exams.	Free	GitHub	Windows	Core member
Manage organization assets, especially make asset retirement decisions	Paid	Linux	Linux	Core member
Monitor Cryptocurrency rates online real time	Free	Bitbucket	Ubuntu	Peripheral developer, Bug fixer, documenter

Table 4 (Cont.)

Brief project description	Contribution Type	Host Platform	Compatible OS	Role(s) of the respondent
This project is for farmers and other agriculture workers in New Zealand and Australia to get weather data, data used for determining when to spray their crops.	Paid	Linux	Linux	Peripheral Developer
Help type 1 diabetics get open access to the data from their glucose meters and share it over the internet	Free	Nightscout	Linux	Architect, but reporter
A musical ear and interval training program.	Free	Sourceforge	Linux	Peripheral developer, bug fixer, bug reporter, and documenter
Restrict Application - it is a powerful parental control software that can easily block adult content.	Free	Sourceforge	Windows	bug fixer

Measures

The focal variables of this study include the five variables in the job characteristics model, job engagement, and job satisfaction. To measure the constructs in our study, we searched for appropriate and already validated scales in the existing literature. All of the measurement items used in this study were collected from existing literature to operationalize the constructs. We used fifteen measurements proposed by the Hackman and Oldham (1980) in their job diagnostics survey (JDS) to measure the *job characteristics*. However, because the context of the study is open source information systems development, we used the JDS items modified by Morris and Venkatesh (2010) whose research job characteristics research was also conducted in the context of information systems. According to the Morris and Venkatesh (2010), they

modified the JDS survey to remove any reverse-coded items for better reliability and validity. *Job engagement* was measured using a five-item scale adapted from Saks (2006). In addition to covering the cognitive, emotional, and behavioral aspect of engagement, the items developed by Saks (2006) also specifically focused on job engagement in relations to the work role played by an employee (Anthony-McMann et al. 2017). We believe the measurement items' focus on the engagement related to work which Saks (2006) argued to be different from organization engagement) makes the items more relevant to our study of the influence of job characteristics on job engagement and job satisfaction. Finally, *job satisfaction* was measured using three items adapted originally from Jansseen (2001) but modified by Morris and Venkatesh (2010). Similar to the use of items for job characteristics, contextual relevance was the logic for using the modified items from Morris and Venkatesh (2010) for measuring job satisfaction.

We included several individual and project related variables in our study to control for alternative explanation. We controlled for individual attributes - gender, age, and education that have been found to be important in many studies that investigated job characteristics, engagement, job satisfaction and other related constructs in the context of information systems (Anthony-McMann et al. 2017; Ho and Rai 2017; Morris and Venkatesh 2010; Rich et al. 2010; Saks 2006). Gender was coded as a binary code: female or male. Education was measured in years of formal education. The respondents were divided into five age groups: below 20 years, 21 to 30, 31 to 40, 41 to 50, and above 50 years. We also controlled for open source project related attributes which have been identified as important factor in open source literature – type of project license, contribution type and tenure in project (Ho and Rai 2017; Setia et al. 2012). The respondents were given four choices for license type: Berkeley Software Definition, General Public, Lesser General public, and other. Contribution type was measured as a binary variable

using free = 1 and paid = 0. Tenure in project was measured in number of years in which months were converted into years.

The items were unchanged if they fit our context. However, some of the items were slightly modified to fit the context of open source development. For instance, the question "In general, how significant or important is your job? That is, are the results of your work likely to significantly affect the lives or well-being of other people?", was modified by adding the phrase 'in the open source project' at the end of the first sentence. Another example of such modification was made to the item, "How much variety is there in your job? That is, to what extent does the job require you to do many different things at work, using a variety of your skills and talents?" by replacing 'at work' in the second sentence with 'in the open source project'. Participants provided their responses to measurement items for all of the focal constructs using Likert-type scales with anchors (1) strongly disagree to (7) strongly agree. The crossed off words or phrases were removed or modified. The words and phrases in *italic* are the additions and modifications for the open source environment questionnaire. Table 5 includes the modifications made to the measurement items for job characteristics. Measurement items for job engagement and job satisfaction are provided in appendix B.

Table 5: Modified measurement items for job characteristics

Job Characteristics
Task Significance • In general, how significant or important is your job *in the open source project*? That is, are the results of your work likely to significantly affect the lives or well-being of other people? • This job is one where a lot of other people can be affected by how well the work gets done. • The job itself is very significant and important in the broader scheme of things.
Task Identity • To what extent does your job *in the open source project* involve doing a "whole" and identifiable piece of work? That is, is the job a complete piece of work that has an obvious beginning and end? Or is it only a small part of the overall piece of work, which is finished by other people or by automatic machines? • The job provides me the chance to completely finish the pieces of work I begin. • The job is arranged so that I can do an entire piece of work from beginning to end.
Skill Variety • How much variety is there in your job? That is, to what extent does the job require you to do many different things ~~at work~~ *in the open source project,* using a variety of your skills and talents? • The job requires me to use a number of complex or high-level skills. • The job is complex and nonrepetitive.
Autonomy • How much autonomy is there in your job? That is, to what extent does your job *in the open source project* permit you to decide on your own how to go about doing the work? • The job gives me considerable opportunity for independence and freedom in how I do the work. • The job gives me a chance to use my personal initiative and judgment in carrying out the work.
Feedback • To what extent does doing the job itself provide you with information about your work performance? That is, does the actual work *in the open source project* itself provide clues about how well you are doing—aside from any "feedback" ~~coworkers or supervisors~~ codevelopers or team members may provide? • Just doing the work required by the job provides many chances for me to figure out how well I am doing. • After I finish a job, I know whether I performed well.

EMPIRICAL ANALYSIS AND RESULTS

Measurement Model Evaluation

To evaluate the measurement model, we tested the reliability and validity of the scales used in our study. For testing the reliability of the measures, we used Cronbach's Alpha.

Cronbach Alphas were as follows: task significance (0.77), task identity (0.71), skill variety (0.69), autonomy (0.82), feedback (0.72), job engagement (0.74), and job satisfaction (0.82). Given that all of the Cronbach Alphas were 0.7 or above, we concluded that all scales were reliable. To assess the convergent and discriminant validity of the survey items a confirmatory factor analysis was conducted on the focal variables using principal components to see if items were loading on the desired variables. Varimax rotation with Kaiser Normalization was used to achieve optimum loading of the items. The rotation converged in seven iterations and converged on seven factors. The Kaiser-Meyer-Olikin measure of sampling adequacy was .85 which can be labelled as "meritorious" indicating that we do not need to examine the anti-image correlation matrix (Kaiser and Rice 1974). The Bartlett's test of sphericity indicates that (Chi-Square =1966.584, $p < .005$) the dataset is appropriate for factor analysis (Bartlett 1950).

All of the item's communality was above 0.5. The factor analysis show that the average factor loading for all factors were above .70 and average variance extracted were above .50, which according to (Fornell and Larcker 1981), indicated good convergent validity of the scale items. All of the cross-loadings were below 0.5 indicating good discriminant validity. For measuring sampling adequacy, we used the Kaiser-Meyer-Olkin (KMO) sampling adequacy test. The KMO test score of 0.85 which is between 0.8 and 1indicated, according to Kaiser (1974), that the sampling was adequate for the factor analysis. The factor loading of the measurement items for all focal variables are presented in Table 6. Finally, we also checked for any common method bias since survey data are prone to such bias (Podsakoff et al. 2003). We conducted Harmon's one-factor test by running an exploratory factor analysis. Since any single factor did not account for the majority of the variance, according to Iyengar et al. (2015), we concluded that there was no common method bias.

As table 6 shows, we excluded two items from the original set of measurement items. We excluded the first item for feedback and the second item for job satisfaction because the items had low factor loading and high cross loadings. The feedback question that was excluded asked "To what extent does doing the job itself provide you with information about your work performance? That is, does the actual work itself provide clues about how well you are doing—aside from any "feedback" coworkers or supervisors may provide?". Because IS professionals participating in open source projects do not have co-workers or supervisors in the traditional sense, we believe these terms did not resonate well with the respondents. The question on job satisfaction that was excluded stated that "I would prefer another, more ideal job". We believe it did not load properly because it was a reverse coded item. In fact, Morris and Venkatesh (2010) mentioned that reverse-coded items tend to give rise to reliability and validity issues.

Table 6: Factor Analysis with Varimax Rotation and Kaiser Normalization

	1	**2**	**3**	**4**	**5**	**6**	**7**
Task Significance 1	**0.84**	0.15	0.07	0.21	0.02	0.05	0.07
Task Significance 2	**0.77**	0.06	0.21	0.17	0.25	0.06	-0.09
Task Significance 3	**0.66**	0.20	0.28	0.13	0.31	-0.01	0.15
Task Identity 1	0.25	**0.87**	0.08	0.10	0.00	0.14	0.12
Task Identity 3	0.09	**0.70**	0.03	0.27	0.44	0.12	0.08
Skill Variety 2	0.30	0.06	**0.76**	0.17	0.26	0.02	0.22
Skill Variety 3	0.17	0.04	**0.86**	0.24	0.05	0.07	-0.17
Autonomy 1	0.26	0.19	0.18	**0.78**	0.01	-0.05	0.14
Autonomy 2	0.18	0.05	0.11	**0.83**	0.26	0.11	0.10
Autonomy 3	0.10	0.15	0.23	**0.70**	0.36	0.10	0.08
Feedback 2	0.26	0.07	0.07	0.35	**0.75**	0.16	0.07
Feedback 3	0.28	0.23	0.31	0.21	**0.67**	-0.01	0.17
Job Engagement 1	0.01	0.14	0.08	0.00	0.07	**0.69**	0.42
Job Engagement 2	0.03	0.06	0.04	0.10	-0.09	**0.89**	0.09
Job Engagement 3	0.07	0.08	-0.01	0.02	0.27	**0.75**	0.31
Job Satisfaction 1	0.02	0.17	0.02	0.16	0.07	0.32	**0.81**
Job Satisfaction 3	0.08	0.02	-0.01	0.12	0.10	0.29	**0.86**

Table 7 includes the descriptive statistics and reliabilities for the focal and control variables. The descriptive statistics shows that the focal variables (job characteristics,

engagement, and job satisfaction) have a higher mean than the center of the scales. Given that this is self-reported data, upward skewness is expected for such variables (Belanger et al. 2001). The upward skewness has been also found in previous literature that studied engagement (e.g., Rich et al. 2010). The upward skewness indicates that the values are potentially not normally distributed. The skewness and kurtosis also indicate normality issue. Hence, we conducted the Shapiro-Wilk test of Normality, which is an effective test of normality for sample sizes less than 5,000 (Razili and Wah 2011). The Shapiro-Wilk test shows that the scores for the focal variables are indeed not normally distributed since the p-values were found to be less than 0.05. Hence, to mitigate the issue of normality, we transformed the variables by using the log function. The log transformation appeared to change the distribution to a more normal distribution. In addition to normalizing the focal variables, we also transformed IS experience, OSD experience, and tenure in project using log.

Table 7: Descriptive Statistics and Reliabilities

	Gender	Age Group	Education	IS Exp.	OSD Exp.	Tenure in Project	Task Sig.	Task Identity	Skill Variety	Autonomy	Feedback	Job Eng.	Job Satisfaction
Mean	0.22	2.73	16.44	8.28	5.24	1.98	5.30	5.31	5.35	5.49	5.57	5.44	5.63
Standard Error	0.03	0.06	0.13	0.48	0.27	0.13	0.08	0.09	0.09	0.08	0.08	0.07	0.08
Median	0.00	3.00	16.00	7.00	5.00	1.33	5.33	5.50	5.50	5.67	5.50	5.50	6.00
Mode	0.00	3.00	16.00	3.00	5.00	1.25	5.67	6.00	5.50	5.67	5.50	5.25	6.00
Standard Deviation	0.41	0.77	1.42	6.11	3.43	1.64	1.05	1.11	1.19	1.05	1.02	0.96	1.06
Kurtosis	-0.10	0.66	-0.77	0.28	0.80	1.19	0.95	0.13	0.07	1.44	0.15	0.50	3.21
Skewness	1.38	0.83	-0.02	1.00	1.16	1.38	-0.74	-0.72	-0.68	-1.02	-0.69	-0.56	-1.33
Range	1.00	4.00	5.00	24.00	14.00	7.08	5.00	5.00	5.00	5.33	4.50	5.25	6.00
Minimum	0.00	1.00	14.00	1.00	1.00	0.08	2.00	2.00	2.00	1.67	2.50	1.75	1.00
Maximum	1.00	5.00	19.00	25.00	15.00	7.17	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Reliability	N/A	N/A	N/A	N/A	N/A	N/A	0.77	0.71	0.69	0.82	0.72	0.74	0.82

Table 8: Correlations

Variables		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Gender														
2	Age Group	-0.05													
3	Education	-0.03	0.14												
4	IS Experience	-0.06	-.45**	-.30**											
5	OSD Experience	-0.06	-.37**	-.36**	.63**										
6	Tenure in Project	0.04	-.18*	0.05	0.08	0.12									
7	Contribution	-0.10	0.10	0.00	-0.14	-0.10	0.05								
8	Project License	.17*	.17*	0.00	-0.06	-0.03	-0.01	0.04							
9	Task Significance	0.15	-0.08	0.09	-0.06	-0.09	-0.13	-.18*	0.00						
10	Task Identity	0.12	-.19*	0.06	0.07	-0.01	-0.11	-.18*	-0.02	.59**					
11	Skill Variety	0.03	0.12	0.04	-0.15	-.22**	-0.13	-0.05	-0.11	.45**	.271**				
12	Autonomy	0.03	-0.06	-0.01	-0.08	-0.13	-.27**	-0.05	-0.08	.44**	.48**	.45**			
13	Feedback	0.08	-0.12	-0.01	0.01	0.04	-0.16	-0.04	-0.09	.57**	.57**	.39**	.53**		
14	Job Engagement	0.09	-0.03	-0.10	0.00	-0.06	-.19*	-0.09	0.05	.49**	.53**	.36**	.49**	.54**	
15	Job Satisfaction	-0.01	0.10	-0.07	-0.08	-0.08	-.19*	-0.04	0.10	.47**	.53**	.31**	.53**	.56**	.59**

Note: *p < 0.05; **p < 0.01

Table 8 provides the correlations after the transformation of the focal variables. The correlations were fairly similar to previous studies that examined relationships between job satisfaction and job characteristics (e.g., Morris and Venkatesh 2010). The mean scores for all five job characteristics were above 5.3 on the scale of 7. The mean score for job engagement was 5.44 and 5.63 for job satisfaction, which were also measured on the scale of 7. The standard deviations for these variables hovered around 1. Several control variables were found to be slightly correlated with the focal variables. Similarly, the five job characteristics were found to be correlated to each other. It should be noted that all of the five job characteristic were found to be significantly correlated with job engagement and job satisfaction. Job engagement was significantly correlated with job satisfaction. These correlations among the focal variables are simply indicative of potential relationship among the job characteristics of an open source project, and the IS professional's job engagement, and job satisfaction on that OSD project.

Theoretical Model Testing

Our research model has two central arguments: job characteristics are important predictors of the job engagement of an IS professional working in the open source development and job engagement mediates the impact of job characteristics on the job satisfaction of that IS professional. Based on the nature of our hypotheses, we used ordinary least squares (OLS) to test our research model. We also tested for any multicollinearity issues using variance inflation factors (VIF). The VIF values in all the models that we testes were well below ten, the acceptable threshold (Gruber et al. 2010; Petter et al. 2007), indicating that there was no serious multicollinearity issue. We conducted the OLS tests in two phases.

In the first phase, we tested the effects of job characteristics on job engagement. We started with the control variables. The results show that none of the control variables had any

significant impact on IS professional's engagement. The model explained 10.37% of the variance in job engagement. Once the impacts of the control variables were tested, we added the five job characteristics in the model. The results show that the job characteristics have strong influence on an IS professional's job engagement in the open source environment given that the influence of OSD experience and payment in the project became insignificant once the job characteristics were added to the mix of predictors. The model explained 47.11% of the variance in job engagement. The variance explained by the main effects model was significantly (36.74%, p-value < 0.001) higher than the model that included only the control variables. The results predicting job engagement are provided in Table 9. We found that two out of the five job characteristics, task identity (B = 0.05, p < 0.01) and feedback (B = 0.175, p < 0.01), have significant positive influence on an IS professional's job engagement in the open source environment. The finding supports hypotheses 1b and 1e. We also found that autonomy does not make any significant difference in the level of job engagement supporting H1d. The results however did not support H1a and H1c.

Table 9: Predicting Job Engagement in OSD

	Control Variables	Main Effects
R^2	0.10	0.47
ΔR^2		0.37**
Gender (1=Female)	0.00	0.00
Age Group	-0.00	-0.00
Education	-0.00	-0.00
IS Experience	0.00	0.00
OSD Experience	0.00	0.00
Tenure in Project	0.00	-0.00
Contribution (1=Free)	-0.00*	-0.00
Project License	0.00	0.00
Task Significance		0.00
Task Identity		0.05*
Skill Variety		0.01
Autonomy		0.05
Feedback		0.18*

Note: $p < 0.05$.

Mediation Analyses

In the second phase, we tested the mediating role of job engagement between job characteristics and job satisfaction of IS professional in open source projects. To test the mediation effect of job engagement, we applied the Baron and Kenny (1986) approach, one of the most well-recognized method for testing mediation effects. The results of the mediation test are provided in Table 10. To establish mediation, the Baron and Kenny approach involves three steps of regression. The first step involves finding that the independent variable(s) have significant effect on the mediator. As we saw in Table 9, two out of the five job characteristics (task identity and feedback) significantly impacts job engagement. The second step in the Baron and Kenny mediation analysis is to show that the independent variable(s) has significant effect(s) on the dependent variable. As we can see in Table 10, both task identity (0.22; $p< 0.01$) and feedback (0.28, $p<0.01$) have significant positive impact on the job satisfaction of an IS professional working in the open source project. The final step in the Barron and Kenny mediation test is that the mediator must significantly affect the dependent variable. As it is shown in Table 10, the mediator job engagement has significant impact on the dependent variable job satisfaction. In addition, when the job engagement is included in the regression along with all of the job characteristics the effect of task identity on job satisfaction become insignificant. In addition, the coefficient for feedback decreased though it remained significant. Thus, the results partially support hypothesis 2 in which the effect of task identity was fully mediated, and the effect of feedback was partially mediated by job engagement.

In addition, we also found that another job characteristics (autonomy) had significant impact (0.220, $p<0.01$) on job satisfaction and remained significant (0.20, $p<0.01$) even when job engagement was added to the regression, though the coefficient was slightly smaller. However,

we cannot conclude that the impact of autonomy was partially mediated since autonomy did not significantly impact job engagement in the second step of the Barron and Kenney mediation test. Task significance and skill variety did not have any significant on either job satisfaction or job engagement. Like the prediction of job engagement, the mediation tests were also conducted in three steps. The first step included only control variables, the second step included the five job characteristics along with the control variables, and job engagement was added in the last step. The variance explained by the main effects model ($R^2 = 0.56$) was significantly higher than the variance ($R^2 = 0.11$) explained by the model that included only the control variables. The mediation model explained 70% of the variance in job satisfaction which was significantly higher than the variance explained by the main effects model.

Table 10: Predicting Job Satisfaction and Testing Mediating Effect of Job Engagement

	Control Variables	Main Effects	Mediation Model
R^2	0.11	0.67	0.70
ΔR^2		0.56***	0.03*
Gender (1=Female)	-.00	-0.00	-0.00
Age Group	0.00	0.00	0.00
Education	-0.00	-0.00	-0.00
IS Experience	0.00	0.00	-0.00
OSD Experience	0.00	-0.00	-0.00
Tenure in Project	0.00*	0.00	0.00
Contribution (1=Free)	-0.00	-0.00	0.00
Project License	0.00	0.00	0.00
Task Significance		0.01	0.02
Task Identity		0.04	0.02
Skill Variety		0.01	0.00
Autonomy		0.22**	0.20**
Feedback		0.28**	0.24*
Job Engagement			0.31*

Note: *p < 0.05; **p < 0.01; ***p < 0.005.

Robustness test using alternative engagement measurements

Since Kahn's (1990) published his research on engagement, it has been studied using several frameworks and measurements have been developed based on these frameworks. Even

though these measurements were geared towards the same concept of engagement, the frameworks and therefore, the measurements using these frameworks, have produced some degree of variation in terms of what they are measuring or what aspects of engagement they are trying to measure (Keenoy 2014). Since, our paper looks at job characteristics, we used the job engagement framework used by Saks (2006) who identified that job engagement is a distinct construct that is directly related to the job. Saks (2006) engagement framework captures the "cognitive, emotional, and behavioral" dimensions of engagement (Anthony-McMann et al. 2017). Even though Saks (2006) developed the measures of engagement building on the multidimensional concept of engagement proposed by Kahn (1990) which included cognitive, physical and emotional aspects, Saks did not necessarily categorize the measures into these dimensions. On the other hand, Rich et al. (2010) developed measures based on specific dimensions of physical, cognitive, and emotional. Therefore, we argue that the measures developed by Rich et al. (2010) provide a viable alternative to test the impact of job characteristics on engagement of IS professionals in the open source development environment. Before we used the Rich et al. (2010) measures, we also conducted tests of reliability and validity of the measures. The Cronbach Alphas for physical engagement, emotional engagement, and cognitive engagement were 0.79, 0.91, and 0.92 accordingly. We also did not find any validity issues with the measures. The factors loadings for the measurement items are included in appendix C. For the alternative models, we tested the impact of job characteristics on all three dimensions of engagement. The results of the alternative models are provided in Table 11.

Table 11: Predicting Job Satisfaction and Testing Mediating Effect of Job Engagement

	Physical Engagement		Emotional Engagement		Cognitive Engagement	
	Control Variables	Main Effects	Control Variables	Main Effects	Control Variables	Main Effects
R^2	0.10	0.56	0.10	0.56	0.08	0.54
ΔR^2		0.46*		0.46*		0.47*
Gender (1=Female)	0.20	-0.44	0.10	-0.10	-0.01	-0.16
Age Group	-0.08	0.10	-0.02	0.20	-0.01	0.19
Education	-0.02	-0.02	-0.01	-0.01	0.00	0.00
IS Experience	-0.04	-0.04	0.01	0.01	0.02	0.02
OSD Experience	0.06*	0.05*	0.04	0.02	0.02	-0.01
Tenure in Project	0.05	-0.10	0.04	-0.02	0.03	-0.03
Contribution (1=Free)	-0.07	0.08	-0.35*	-0.19	-0.28	-0.12
Project License	-0.06	0.04	-0.11	-0.03	0.11	0.19
Task Significance		0.09		0.12		0.12
Task Identity		0.22**		0.13		0.08
Skill Variety		0.08		0.03		0.09
Autonomy		-0.03		0.23**		0.32***
Feedback		0.48***		0.37***		0.23**

Note: $p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.005$.

The results are mostly consistent to the findings in the original model proposed in this paper using job engagement. For instance, we found that both task identity and feedback significantly influenced physical engagement. This finding is similar to the finding in the testing of the original model where we also found that task identity and feedback significantly and positively influenced job engagement of IS professionals in the open source environment. So, the results for physical engagement were quite similar to the results on the job engagement. The results are somewhat similar given that feedback significantly impacted emotional engagement and cognitive engagement. However, task identity was not found to be a significant factor of influence for cognitive and emotional engagement even though it was found to significantly impact job engagement. In addition, we found that autonomy significantly impacted both emotional and cognitive engagement. Given that task identity, autonomy, and feedback

influenced physical, emotional, and cognitive engagement of IS professionals in the open source environment, even though varying on the level of significance, we argue that job characteristics is an important and robust theoretical lens for studying engagement of IS professionals in the open source environment. The main effects models explained 55.7%, 56%, and 54.3% variance in the physical engagement, emotional engagement, and cognitive engagement accordingly. All three main effects models explained significantly higher variance than the models that included only the control variables.

DISCUSSION

Managing IS project is always a challenge. The IS professionals are usually highly skilled and well paid. Software development in the OSD adds another layer of complexity in the process of project development for the IS project managers. Research shows that, as organizations, both private and government, become more and more interested in the new and unique way of software development, IS project managers and researchers are looking at various factors that trigger and stabilize participation of IS professionals in OSD projects (e.g., Maruping et al. 2019; August et al. 2018; Hahn et al. 2008; Ho and Rai 2017). The existing literature in the open source domain have two major streams: one stream examines the attributes of the individuals (e.g., commitment, motivations) contributing to OS projects and the other examines the attributes of OS projects (e.g., project size, quality control). However, there is a lack of research in the open source domain that are focused on attributes that are directly tied to the roles played by IS professionals working in these open source projects. Our research intends to enhance the second stream of research by looking at role-specific project attributes in the open source environment and how these attributes influences the relationship between the IS professional and his or her work role in OS projects.

Hence, the primary goal of our paper was to explore role-specific project attributes that can positively influence engagement among IS professionals working in the OSD environment. By studying the psychological concept of engagement, we hope to provide a comprehensive understanding of the relationship between IS professionals and the work roles they play in the open source software development. To achieve our goal, we used the job characteristics model (Hackman and Oldham 1980) as a theoretical lens. Job characteristics model helped us in three distinct ways. First, because payment is not a factor for the job characteristics in JCM, the theoretical model was directly useful in the open source development environment where majority of workers are not directly paid for their contribution. The second advantage provided by JCM was that it provided us the right set of attributes that we would like to examine as antecedents of engagement. Third, because job satisfaction is an integral part of JCM, using JCM in the context of OSD provided us an opportunity to extend JCM as we explored where engagement would fit in the nomological network of job characteristics and job satisfaction. Using the job characteristics model, we propose a middle-range theory (Van de Ven 2007, p.142) in which we examined how job characteristics (task significance, task identity, skill variety, autonomy, and feedback) impact job engagement of an IS professional and whether job engagement plays a mediating role between job characteristics and job satisfaction in the open source environment. We used a survey design to ask participants, who are currently contributing or have recently contributed to open source software development, questions about their job engagement, the characteristics of their job in the open source project they were working and their job satisfaction.

The results corroborate three of the five hypotheses that are related to predicting job engagement. As hypothesized, the results show that task identity and feedback positively

influence an IS professional's job engagement in the open source environment. The results also supported the hypothesis that autonomy in open source projects will not have any sway on the job engagement of an IS professional. However, the results did not support our hypotheses that task significance and skill variety will positively impact an IS professional's job engagement in the open source environment. The results support the premise that project attributes that are specific to the role(s) played by an IS professional in the open source are important attributes for understanding the engagement of these professionals. The control variables' model showed that an IS professional's experience in the open source environment and whether s/he is paid in the project are important factors that drive job engagement. However, when the job characteristics were added to the model, OSD experience and payment became insignificant. This finding shows that the JCM and the job characteristics that are part of the Hackman and Oldham (1980) model are important antecedents of job engagement, important enough that they can offset the significance of OSD experience and payment.

The results also corroborate the hypothesis that job engagement plays a mediating role in the relationship between job characteristics and job satisfaction of an IS professional working in an open source project. The findings showed that job engagement fully mediated the impacts of task identity and feedback on the job satisfaction. Task significance and skill variety did not have any significant direct impact on job satisfaction and therefore no mediation is discernible for these two variables. Since, job engagement was found to mediate two of the five job characteristics' effect on job satisfaction, our findings support the premise that job engagement is an important construct in the relationship between job characteristics and job satisfaction.

Theoretical Implications

Our study makes four theoretical contributions. First, we enhance the open source literature by examining role-specific project attributes that are important for engaging IS professionals in open source projects. The existing literature's focus on factors such as social identity, commitment to company and OS community, altruism (e.g., Hars and Ou 2002; Bagozzi and Dholakia 2006; Alam and Campbell 2017; Maruping et al. 2019) helps us understand why individuals join and continue to contribute in OS projects. The literature's focus on general project attributes such as quality control, type of project, OSS product quality (e.g., Ho and Rai 2017; Setia et al. 2012) helps us understand the attributes related to OS project design that may encourage participants to join and continue their contribution. Our study contributes to this effort of project design by looking at role-specific attributes that will enhance the level of job engagement of those who will contribute to such OS projects. For instance, the importance of task identity in driving IS professional's job engagement should encourage designing of an OS project where roles are tied to an optimum portion of the project's workload.

Second, job characteristics model has helped IS researchers to understand how various work outcomes can be influenced by job characteristics in the proprietoy environment (e.g., Morris and Venkatesh 2010; Rich et al. 2010; Tripp et al. 2016). Our study shows that JCM can provide valuable insights about IS professionals in the open source environment as well. In other words, as Whetten (2008) suggested, by applying the well-established theoretical lens of JCM to an emerging field we make a contribution of the theory to the open source literature. Third, the literature on job satisfaction in the OSD environment is still at its nascent stage, but we are observing few studies (e.g., Casalo et al. 2009; Gerede and Mazan 2018). Our study shows that job engagement plays a mediating role between the job characteristics and job satisfaction. By

adding the mediating effect of engagement, this research enriches the IS literature by extending the JCM model that has been highly studied in the IS domain (e.g., Morris and Venkatesh 2010) that shows a direct effect of job characteristics on job satisfaction. In other words, we also contribute to the theory (Whetten 2008) by extending JCM.

Fourth, our study enriches the engagement literature by applying the concept of engagement in the IS field, and specifically in the open source domain. Engagement has been identified by many in the management literature as a very important construct that helps us understand the relationship between a person and his or her work role. Many management and organizational behavior scholars (Kahn 1990; Harter et al. 2002; Saks 2006; Rich et al. 2010; Soane et al. 2012; Anthony-McMann 2017) have found that engagement leads to various positive individual and organization outcomes. We enhance this stream of literature by studying antecedents and outcomes of job engagement in the open source domain. Moreover, to the best of our knowledge, our study is the first study in engagement that tests the impact of job characteristics on job engagement, physical engagement, emotional engagement, and cognitive engagement in the same study. By utilizing measurement items developed by both Saks (2006) and Rich et al. (2010) we cover two dominant perspectives of engagement and thus enrich the engagement literature.

Managerial Implications

More private and public organizations are relying on OSD for software development (August et al. 2018). Government organizations such as Data.gov is using OSD through GitHub (Data.gov 2018). Prominent private software organizations such as Google and Microsoft have joined OSD (Ho and Rai 2017). This study will provide guidance to organizations that are either exploring or already involved in utilizing the OSD to accomplish projects needed for the

organization that would have been previously done in the PSD environment. The study will also help private citizens who use the OSD to procure software for their own necessity by guiding them to design project that includes job characteristics that are appealing to the IS professionals.

Limitations and Suggestions for Future Research

Open source software development is neither a new a nor a matured domain. There are tremendous opportunities in OSD that are yet to be explored by the world. We believe our study makes another small advancement in our understanding of this amazing phenomenon. There are several limitations to our study that can lead to opportunities for future research in the open source development environment. For instance, engagement has been found to significantly influence many individual work outcomes in the existing literature. Since we focused on the job characteristics model as our theoretical framework, we have only examined job satisfaction as the outcome of job engagement. Future researchers can examine whether job engagement can lead to better performance or lesser turnover in open source projects. Turnover is especially very important given that the highest percentage of open source project failure are attributed to turnover of developers (Fang and Neufeld 2009; Maruping et al. 2019).

Future researchers can also look at the organizational aspects of engagement in the open source domain. For instance, Saks (2006) has conceptualized job engagement to be distinctly different from organization engagement. While IS professionals working in open source projects are not necessarily employed by an organization, they have relationships with potentially two types of organizations – organization that provides the platform to develop the open source software and the organization that owned/initiated the open source project (if owner/initiator of the OS project is an organization). Future researchers may examine antecedent (e.g., job characteristics) and consequences (e.g., organizational citizenship behavior, organizational

commitment) of the IS professional's engagement (organization engagement) in the OS platform or the owner/initiator organization.

In our study, we hypothesized and found that autonomy in open source projects does not significantly impact job engagement. However, we did find that autonomy significantly impacts job satisfaction of IS professionals in open source software development. We also noted that the level of significance did not change when job engagement was added to the regression. Hence, future researchers can examine the role of autonomy in open source projects with more focus on this construct. For instance, future researchers can examine whether autonomy may impact organization engagement since the organization would be the entity that manages the level of autonomy an IS professional would enjoy in an open source project. Future research may also try to understand what is the optimum level of autonomy that is beneficial to most open source projects, or what type projects would benefit from high level of autonomy and what type of projects would not.

We utilized existing job characteristics, engagement, and job satisfaction measurement items with minimal modification to fit the open source context. However, as the open source domain continues to make more impact in the world, it may worth time and effort to develop and test new set of measurement item that are specifically designed for the context of open source software development. Future researchers may conduct a mixed method study by starting with a qualitative study that will allow them develop measurement items for the OS context and then applying those measurement items in a quantitative study. The qualitative study will allow future researchers to capture the richness of the open source context and the quantitative study will allow them to evaluate the measurement model.

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APPENDICES

Appendix A: Job Characteristics research in the IS literature

Reference	Independent Variables	Dependent Variables
Goldstein and Rockart 1984	Skill variety, autonomy, task identity, task significance, feedback from job	Job Satisfaction
Specht 1986	Job complexity, task analyzability, task identity, job level, routine clerical decision making, managerial decision making, strategic decision making	Data quality requirement, data manipulation requirement, special reports requirement
Kaplan and Duchon 1988	Skill variety, task identity, autonomy, and feedback.	Computer system variables
Igbaria et al. 1994	Job Characteristics in terms of intrinsic and extrinsic rewards	Job Involvement, job satisfaction, organizational commitment
Morris and Venkatesh 2010	Skill variety, autonomy, task identity, task significance, feedback	Job satisfaction
Venkatesh et al. 2010	Skill variety, autonomy, task identity, task significance, feedback	Job satisfaction, performance
Bala and Venkatesh 2013	ES implementation, change in job Characteristics (job demands, job control)	Job Satisfaction
Tripp et al. 2016	Extent of use of Agile PM practices, Extent of use of agile SDA practices, Skill variety, autonomy, task identity, task significance, feedback	Job Satisfaction

Appendix B: Measures for Engagement and Job Satisfaction

Job Engagement (Saks 2006)

- I really "throw" myself into my job in the open source project.
- Sometimes I am so into my job that I lose track of time.
- This job is all consuming; I am totally into it.
- My mind often wanders and I think of other things when doing my job (R).
- I am highly engaged in this job.

Job Satisfaction (Morris and Venkatesh 2010)

- Overall, I am satisfied with my job in this specific project in the open source environment.
- I would prefer another, more ideal job in open source project. (reverse score)
- I am satisfied with the important aspects of my job in this open source project.

Physical Engagement (Rich et al. 2010)

- I work with intensity on my job.
- I exert my full effort to my job.
- I devote a lot of energy to my job.
- I try my hardest to perform well on my job.
- I strive as hard as I can to complete my job.
- I exert a lot of energy on my job.

Emotional Engagement (Rich et al. 2010)

- I am enthusiastic in my job.
- I feel energetic at my job.
- I am interested in my job.
- I am proud of my job.
- I feel positive about my job.
- I am excited about my job.

Cognitive Engagement (Rich et al. 2010)

- *While I work*, my mind is focused on my job.
- *While I work*, I pay a lot of attention to my job.
- *While I work*, I focus a great deal of attention on my job.
- *While I work*, I am absorbed by my job.
- *While I work*, I concentrate on my job.
- *While I work*, I devote a lot of attention to my job.

Appendix C: Factor Analysis of Physical, Emotional and Cognitive Engagement Measures

	1	**2**	**3**
Physical Engagement 1	**0.786**	0.170	0.290
Physical Engagement 2	**0.821**	0.143	0.275
Physical Engagement 3	**0.680**	0.557	0.023
Emotional Engagement 2	0.307	**0.702**	0.489
Emotional Engagement 4	0.164	**0.761**	0.377
Emotional Engagement 5	0.192	**0.725**	0.494
Emotional Engagement 6	0.273	**0.724**	0.402
Cognitive Engagement 1	0.256	0.428	**0.692**
Cognitive Engagement 2	0.232	0.362	**0.742**
Cognitive Engagement 3	0.257	0.308	**0.801**
Cognitive Engagement 5	0.286	0.422	**0.711**
Cognitive Engagement 6	0.134	0.231	**0.822**

Essay 2

EXPLORING THE RELATIONSHIP BETWEEN INFORMATION SYSTEMS PROFESSIONALS AND OPEN SOURCE SOFTWARE DEVELOPMENT PLATFORMS: AN ORGANIZATIONAL JUSTICE PERSPECTIVE

ABSTRACT

Organizations, both public and private, are becoming more invested in open source software development. Organizations that heavily resisted this new way of developing software are now actively participating in this process. However, continued voluntary participation remains a concern and a topic of great interest in the information systems literature. Even though we cannot emphasize enough about the contributions made by the open source platforms that have facilitated these innovative processes, the existing literature has been overly focused only on continued participation from individual project's perspective. In other words, there is a lack of research that examines the relationship between individual contributors and open source platforms. Our study examines this relationship in terms of continued voluntary participation in open source platforms and engagement in these organizations. Using the social exchange theory as the overarching theoretical framework, this study explores how perceptions of justice in rewarding individuals in open source projects may influence their engagement in the platform organization and their intention to contribute in future activities hosted by the platform. The study included responses from 109 information systems professionals who worked in various open source projects in which they received some form of reward. This study finds that multiple dimensions of justice perception of IS professionals working in open source projects significantly influence their engagement in platform and continued participation intention in the platform activities. The research enriches the open source literature by focusing on the relationship between IS professionals working on open source projects and the platforms that are

hosting these projects. The study also provides insights for open source platforms that have a desire and the need for continued voluntary participation and engagement from IS professionals for the platform to remain popular in the open source community.

Keywords: Open source, software development, participation, reward, recognition, justice, and organization engagement, platform engagement.

INTRODUCTION

Open source (OS) is the new of way of creating knowledge and software products where "the economics of private goods, built on the scarcity of resources, is replaced by the economics of public goods, where scarcity is not an issue" (Hars and Ou 2002, p. 25). In absence of contractual or financial agreement, voluntary participation is at the core of open source initiatives (Hertel et al. 2003; Benkler and Nissenbaum 2006, Smith-Yoshimura and Shein 2011, Alam and Campbell 2012, Alam and Campbell 2017; Ho and Rai 2017). In fact, lack of voluntary participation has been found to affect a large percentage of open source software development (OSSD) projects (Fang and Neufeld 2009). Hence, what factors influence the intention of volunteers to continue to contribute remains an important question (Ho and Rai 2017). There is a good amount information systems (IS) research that have explored various factors that can influence participation of IS professionals in the OS environment. A large portion of the extant literature in this IS research stream is focused on motivations, and a whole host of intrinsic and extrinsic motivations have been examined (Alam and Campbell 2017; Hars and Ou 2002; Hertel et al. 2003). Given that open source contribution is free, and volunteer based, project attributes are also naturally very important factors that make volunteers interested to participate. Project attributes such as quality control and project type have been found to influence continued voluntary participation (Ho and Rai 2017). Relationship among IS professionals is also an

important factor that influences participations. For instance, (Hahn et al. 2008) found that prior collaboration ties tend to significantly influence an IS professional's decision to join a new OSSD project. Table 1 below lists a few notable studies that have looked at the question of participation of IS professionals in open source projects.

The existing literature, however, looked at the matter of continued participation primarily from the project perspective. In other words, questions studied in the open source literature looked at what may influence IS professionals to continue to participate in specific OSSD projects. While looking at continued participation in OSSD projects is indeed very important, it does not tell us about how the IS professionals' experience in the OSSD projects shape their feelings towards the OS platforms that hosted the projects. It is technically possible to develop and disseminate an open source software by an individual developer, it does not make any business sense since a platform would tremendously help the process of dissemination. In addition, platforms allow IS professionals to know about other ongoing projects and find suitable areas where they would like to contribute. Therefore, it is important to understand the relationships between individual IS professionals and open source platforms, especially in the matter of continued participation in future platform activities (e.g., new OS projects, competitions). However, the literature is yet to examine what factors may influence an IS professional to continue to participate in an open source platform. We address this gap.

Table 1: Notable IS research on volunteer participation in open source innovation

Reference	Independent Variable(s)	Dependent Variable(s)
Alam and Campbell 2017	Intrinsic motivation, extrinsic motivation	Volunteer participation in cultural crowdsourcing work
Bagozzi and Dholakia 2006	Social identity, identification, emotions, attitudes, experience with the platform	Participation intentions
Blanchard and Markus 2004	Feelings of membership and influence, integration and fulfillment of needs and shared emotional connection	The sense of virtual community
Daniel et al. 2018	Ideology, commitment to company, commitment to OSS community	Continued code contribution
Fang and Neufeld 2009	Situated learning, identity construction	Long-term voluntary participation
Faraj and Johnson 2011	Direct reciprocity, indirect reciprocity, preferential attachment	
Faraj et al. 2011	Tension resulting from the fluidity	Participation
Hahn et al. 2008	Cohesion cues and status cues based on the developer's past collaboration	Join
Hann et al. 2004	Social-psychological functions (normative, values, understanding, career concerns, and ego enhancement)	participation
Hars and Ou 2002	Self-determination, altruism, community identification, future rewards, personal need	Participation
Hertel et al. 2003	Valence, instrumentality, self-efficacy, and trust	Participation
Ho and Rai 2017	Quality control, type of project, tenure in the project	Volunteers continued participation intention
Lerner and Tirole 2002	Career concern incentive, ego gratification incentive	Participation
Ma and Agarwal 2007	Perceived identity verification, satisfaction	Knowledge contribution
Maruping et al. 2019	Developer open source values, centrality in communication network, commitment to open source community	Code contribution activity
Nambisan and Baron 2010	The sense of responsibility to community and company, expectations of self-image and expertise enhancement, identification with community and company	Contribution
von Hippel and von Krogh 2003	Private-collective model of innovation (Private rewards)	Contribution

There are two types of organizations that are involved the open source environment. One type of organization is the platform organization that hosts the development of the software. The other type of organization is the organization that owns or initiates an open source project. However, we must note that a vast majority of OS projects are owned or initiated by private individuals or group of individuals but usually all OS projects do require a platform that hosts and helps make the software and/or code available to others. Given that there is no financial or other forms of contract that binds an IS professional to an OS platform organization, we argue that the ongoing relationship between an IS professional and an OS platform is shaped by the experience the IS professional gains from working in various OS projects hosted by the OS platform. While the OS platforms do not usually get involved in direct payment to participants for participating in projects hosted by the OS platforms, they are indeed directly or indirectly involved in the process of giving various forms of rewards to the contributors. Sometimes this recognition is embedded in ongoing projects in the platform and participants are ranked for the level of participation (Roberts et al. 2006). Sometimes platforms arrange or host special competitions and provide monetary rewards for succeeding in those competitions. We argue that the object of reward, how these rewards are determined, and how well these determination procedures are communicated in OS projects play a role in developing a relationship between the OS platform and the IS professional participating in the projects hosted by the platform. In other words, IS professionals develop a perception about the reward system, and we argue that this perception plays a role in influencing the IS professionals' decision to come back to join another project in future hosted by the same OS platform. In the psychology literature, such perception is known as the perception of justice. Perception of justice refers to the fairness of the outcome, both the substance and the process, a person receives from an organization or an authority

(Colquitt et al. 2013). The justice lens provides us a framework that helps measuring the individual perception of justice in terms of the level of rewards an IS professional received, the procedure followed to determine the rewards, the clarity in communication, and how this perceptions of justice can lead to a social exchange of reciprocative behaviors from the IS professional to continue to participate in projects or activities hosted by the OS platform. Justice researchers argue that individuals view perception of justice as a "symbolic resource" that generates reciprocative behaviors from the perceiver (Colquitt et al. 2013). Let's put this in the context of Kaggle.

For instance, Kaggle routinely hosts competitions that could reward thousands of dollars to the winner(s). As of November of 2019, Kaggle had successfully arranged and completed hundreds of competitions that rewarded thousands of dollars to the winning teams or individuals (Kaggle 2019). In fact, we have seen the question of fairness come up in various discussion boards in Kaggle. We have also seen Kaggle's team is actively responding to resolve any concern, which shows that OS platforms do care about maintain the atmosphere of fairness. Figure 1 and Figure 2 show screen captures from a discussion thread from Kaggle. Figure 1 shows the concern of the discussion leader. Figure 2 shows the response from the Kaggle team (of course, there are many other responses provided by other members that are not listed in the figure and individually identifiable items are redacted). We argue that if IS professionals feel that rewards were given fairly in these competitions, they will be encouraged to join another OS project or competition hosted by Kaggle in future.

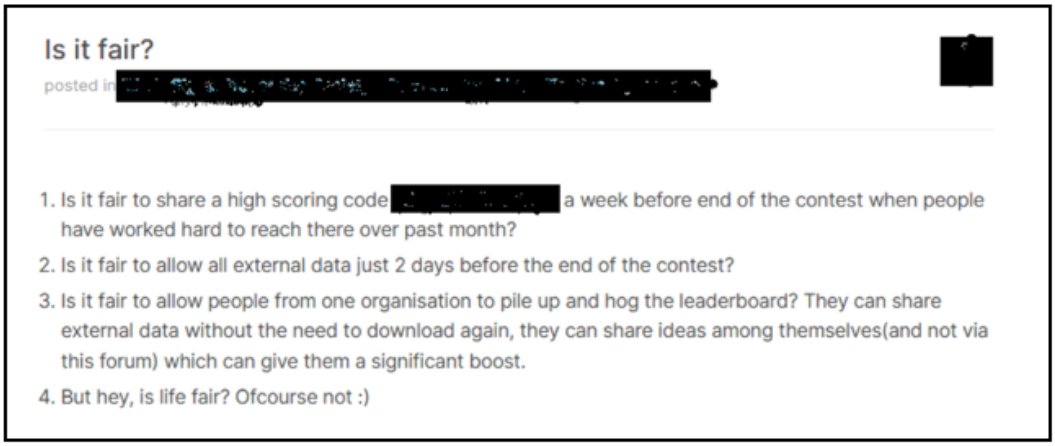

Figure 1: Concerns raised by discussion leader[5]

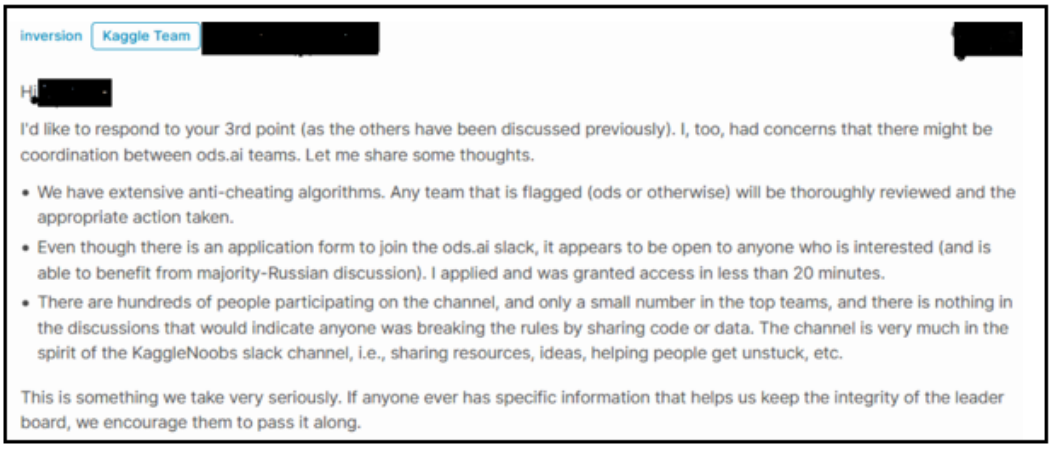

Figure 2: Response provided by the Kaggle Team[6]

In addition to continued participation in platform activities, we also examine engagement of IS professionals in the platform. Engagement is a psychological construct which refers to the investment of physical, emotional and cognitive abilities of a person to achieve success in performing his or her work role (Kahn 1990). While engagement to work or job has been at the center of the engagement literature, there has been research that also examined an individual's engagement in his or her organization (Anthony-McMann et al. 2017). Engagement has been found to lead to many individual and organizational outcomes. One of the most relevant outcomes to organization is organization commitment (Saks 2006). Hence, we argue that

[5] The discussion thread is collected from Kaggle; retrieved from https://www.kaggle.com/

examining engagement along with continued participation in open source platforms would greatly bolster our understanding of relationships between individual IS professionals and OS platforms in open source software development. Saks (2006) first conceptualized that an employee's engagement in his or her work is distinctively different from his or her engagement in the organization and referred to it as organization engagement. in the context of OS environment, we coined this relationship as *platform engagement,* and examined how justice perceptions about rewards, developed while working on individual OS projects, can strengthen or weaken the relationship between an IS professional and an OS platform.

To understand the consequences of justice, researchers in the organizational justice literature have predominantly relied on the social exchange theory (Colquitt 2008). Social exchange theory propagates that a person will develop an exchange relationship with others when he or she expects to exchange something valuable (Flynn 2005). Reciprocity is at the heart of all social exchange "because humans keep score, assign meaning to exchanges, and change their subsequent interactions based on a reciprocity balance" (Faraj and Johnson 2011, p. 1468). Using the social exchange theory as the overarching theoretical framework, this study explores how perception of justice in rewarding individuals in open source projects may influence their engagement in the platform organization and their intention to contribute in future activities hosted by the platform. In brief, our proposed research model looks at the impact of distributive justice, procedural justice, and informational justice on IS professionals organization engagement in the open source platform and intention to continue to participate in future platform activities. To test our proposed research model, we used a survey study design to interview IS professionals working on various types of OSSD projects that serves educational, gaming, communication and several other industries. The host platforms for the projects included but not limited to well-

known OSSD platform such as GitHub, Sourceforge, Kaggle, and Linux. A total of 109 IS professionals' responses were included in our final analysis. The respondents' roles ranged from peripheral developer to core member. The results are supportive of the central assertion that justice perceptions are important to IS professional's platform engagement and continued participation in open source platforms.

The study sheds light on an aspect in open source software development that has not been studied previously. Perception of justice has been found to be an important factor that can influence individual behavior and performance in the workplace. For instance, perception of justice has been found to influence engagement of IS professionals working in IS projects and project performance (Bhuiyan and Setia 2018; Bhuiyan and Setia 2017). This study should provide us empirical example of how perception of justice can play a role also in the open source domain. The study also enhances the IS literature by applying the social exchange theory in the open source context. There is a tremendous interest in organizations to explore and utilize the OS environment for software development (Ho and Rai 2017). In the absence of financial obligations, it is natural for organizations to assume that participation of volunteers in open source project is free of the influence of perception of justice. This study should inform organizational IS managers that even though it is subtle, the importance of justice perceptions does not completely fades away in the open source environment.

THEORY

We design this section in three subsections; we start by defining the constructs. The core sets of the constructs in our research model include distributive justice, procedural justice, informational justice, intention to participate in future platform activities, and platform

engagement. Then we propose our research model and conclude with our justifications of the hypotheses in our research model.

Construct Definitions

The first set of constructs are related to perception of justice. These justice constructs were adapted from Colquitt (2001). Most scholars who studied justice constructs, including scholars in the IS literature (e.g. Xue et al. 2011), used the justice dimensions defined and measured by Colquitt (2001). Colquitt tied perception of justice to outcomes received by an individual at work. Outcome, according to Colquitt (2001), is something that an employee receives in return for his or her service to an organization. Since majority of IS professionals working in the OS environment are volunteers, we counted various forms of rewards they received while working on open source projects as the outcomes. In Merriam-Webster[6] dictionary, reward refers to "something that is given in return for good or evil done or received or that is offered or given for some service or attainment" and recognizing means "to acknowledge or take notice of in some definite way: such as … to acknowledge with a show of appreciation." According to Maslach et al. (2001), there are three types of rewards: financial rewards, social rewards, and intrinsic rewards. They appear to use recognition and social reward interchangeably by describing that "lack of social rewards, as when one's hard work is ignored and not appreciated by others. This lack of recognition devalues both the work and the workers" (Maslach et al. 2001, p. 415). Others have also defined rewards as "something of value that produce pleasure or satisfaction can be either intrinsic or extrinsic" (Kellye and Protisk 1997, p. 475). Saks and Gruman (2014), in their review of engagement literature, also used rewards and recognitions interchangeably. This notion leads us to identify recognition being a form of

[6] https://www.merriam-webster.com/dictionary/reward

reward. Hence, we defined the distributive, procedural, and informational justice in relations to various forms of rewards (e.g., financial rewards or recognitions or promotions to higher ranks) received by IS professionals in open source projects.

We define *distributive justice* as the extent of fairness in the rewards related to the input provided by an IS professional in an open source project. *Procedural justice,* in this study, refers to the fairness in the process of determining the recipient to receive a reward for contributing in an open source project. We define *informational justice* as the fairness in information sharing by the OS platform or the project leader(s) that is necessary for an IS professional to succeed in receiving a reward. We adapted our definition of informational justice from IS researchers, Xue et al. (2011), who referred to informational justice as "the perception of fairness resulting from being provided with explanations for the decision" in their study of punishment in mandatory information technology settings (p. 404). We define *intention to participate in future platform activities* as the level of participation an IS professional intends to commit in future activities hosted by a specific open source development platform (e.g. Sourceforge). We adapted the continued participation intention from Ho and Rai (2017). We define *open source platform engagement* as the engagement of an IS professional in the open source platform that is hosting the open source project in which the IS professional is contributing. We adapted platform engagement from the concept of organization engagement proposed by Saks (2006) who defined organization engagement as the engagement of an individual in his or her organization. Saks' (2006) conceptualization of organization engagement identifies it as the construct that is different from job engagement (an individual's engagement is his or her job).

Research Model and Theoretical Background

Our research model attempts to examine two relationships. First, we examine how perceived justice of rewards in open source projects may influence an IS professional's engagement in the platform that hosted the open source project. Second, we examine how perceived justice of rewards may influence an IS professional's intention to participate in future activities of an open source development platform. To examine these relationships, we take guidance from the social exchange theory (SET). The history of SET dates back to early twentieth century, and the application of SET is documented across a number of social science studies (Cropanzano and Mitchell 2005). "Social exchange theory can be viewed as a multidisciplinary paradigm that describes how multiple kinds of resources can be exchanged following certain rules and how such exchanges can engender high-quality relationships" (Colquitt et al. 2013, p. 200).

Even though very limited, the use of social exchange theoretical framework is not entirely new in the open source research. Faraj and Johnson (2011) used the social exchange perspective to understand the relationship building in open innovation communities. By simultaneously applying the social exchange and network perspective, they argue that "the social aspect of the network is made even more salient by technological mediation of interaction" (p.1466). Their study implies the importance of examining the social exchange that occurs in open innovation networks. We argue that open source development platforms (e.g., GitHub) fit the definition of an open innovation network that facilitates the collaboration of IS professionals to create new products and knowledge. There are commercial and non-commercial benefits for open source platforms to retain and engage developers in platform activities (Lerner and Tirole

2005). In this study, we examine the social exchange dynamics of justice perception and participation of IS professionals in open source software development platforms.

According to various justice researchers, justice in workplace represents a type of resource that encourages positive reciprocative behaviors and vice versa (Cropanzano and Byrne 2000; Colquitt 2008; Cropanzano and Rupp 2008; Colquitt et al. 2013). While the open source innovation platforms are not workplace from a traditional point of view, open source platform activities to innovate do require an investment of cognitive, physical, and emotional capabilities and therefore justice perception should play a role in the open source domain as well. Therefore, we argue that the existence of justice (or lack of it) will play a role in the social exchange between the open source platform and the individual IS professionals who are working on OS projects hosted by these platforms.

However, in the absence of direct payment or reimbursement systems in the open source development environment, the development of justice perception will be much subtler, and we will need to look closely in the motivations for open source participation. The OSSD literature provides us a list of intrinsic and extrinsic motivations for participation. However, we can exclude the intrinsic motivations since it only serves the self and therefore the question of justice is not relevant. Next, we look at the extrinsic motivations. For instance, Roberts et al. (2006) and Hars and Ou (2002) provide a list of extrinsic motivations: community identification, revenues from related products and services, opportunity to expand skills, self-marketing, and reward and recognition. We argue that this motivation for "reward and recognition" mentioned by Har and Ou (2002) is the aspect in which the justice perception can be salient. Figure 3 presents our proposed research model.

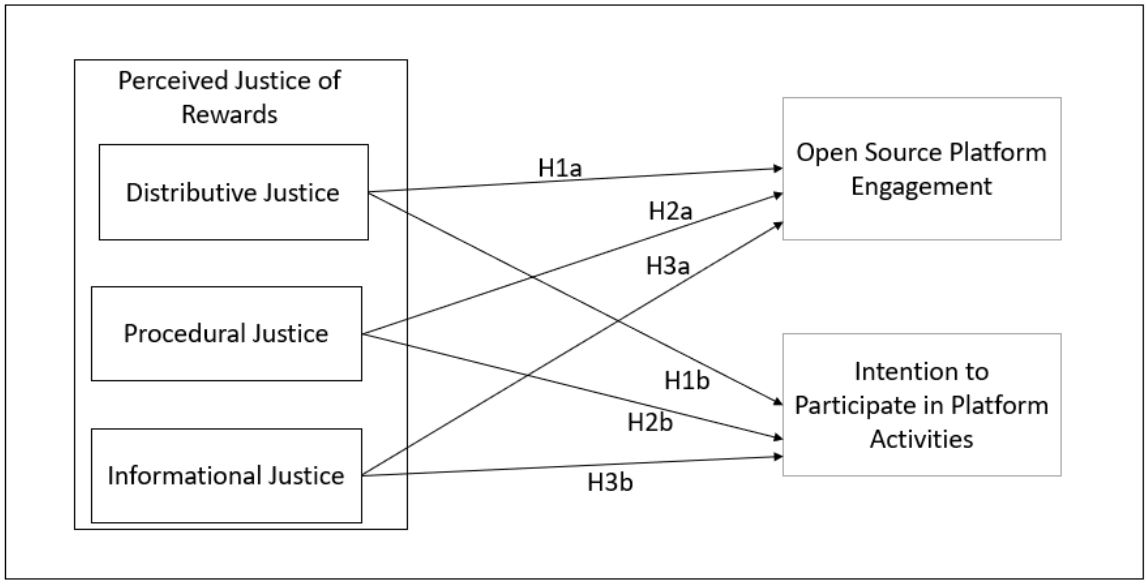

Figure 3: Proposed Research Model

Hypotheses Development

There are three forms of social exchange: negotiated, reciprocal, and generalized (Flynn 2005). Even though Emerson (1976) referred to another form of social exchange called productive exchange, subsequent researchers put this in the generalized form (Flynn 2005). The negotiated and the generalized forms of social exchange serves solely self-interest and group interest accordingly. The reciprocal form of social exchange, however, can serve both self-interest and other's interest. Flynn (2005) notes that this reciprocal form of social exchange can involve direct reciprocation but does not necessarily involve explicit discussion of exchange terms. We argue that participation of an IS professional in an open source platform activity does involve reciprocal form of social exchange since IS professionals are motivated by both intrinsic and extrinsic motivations as noted by many researchers (e.g., Roberts et al. 2006). Next, we look at how perception of justice plays a role in the reciprocal form of social exchange. According to Colquitt (2013) employees feel obligated to reciprocate with behaviors that are conducive to the organization's goals. Justice perceptions tend to trigger a reassessment of inputs by an employee

to an organization (Colquitt 2013). If the employee perceives positively, s/he feels obligated to reciprocate with behaviors that is conducive to the organizational performance (Colquitt et al. 2013; Zhang et al. 2014). Researchers have found positive justice perceptions to positively influence compliance of rules and laws (Xue et al. 2011; Colquitt 2001), promote a positive relationship between team members and team leader (Colquitt 2001; Masterson et al. 2000; Cropanzano et al. 2002), increase organizational citizenship behavior and job and organization engagement (Saks 2006). Following this logic of reciprocal form social exchange of justice and positive reciprocation behaviors, we argue that a similar reciprocal form of social exchange occurs in the open source environment.

Even though the IS professionals participating in OS platform activities do not get directly paid for their contributions especially in the projects in which they are working as volunteers, we argue that they will develop a perception of justice based on the level of reward they receive in the open source projects. Many researchers (e.g., Cropanzano and Byrne, 2000; Rupp, et al. 2001; Cropanzano and Rupp, 2008) suggested that "justice reflects the sort of symbolic resource that should foster reciprocative actions on the part of employees" (Colquitt et al. 2013, p. 201). Maslach et al. (2001) in their engagement model showed that engagement at work is positively related to perception of justice and disengagement prevails when there is a lack of justice in the outcome people receive at work. "In other words, when employees have high perceptions of justice in their organization, they are more likely to feel obliged to also be fair in how they perform their roles by giving more of themselves through greater levels of engagement" (Saks 2006, p. 606).

We argue that if an IS professional perceives a level of reward is deficient compared to the level of contribution made them in OS projects, they will feel disengaged not only in the

specific OS project but also to the platform organization that is hosting the OS project. Though it has been documented that a large number of OS projects fail because volunteers leave projects (Fang and Neufeld 2009), because IS professionals contributing in open source projects are highly driven by intrinsic and extrinsic motivations (Roberts et al. 2006; Alam and Campbell 2018), it is arguably possible that an IS professional will continue to work in a specific project, to ensure either s/he reached a certain sense of accomplishment or s/he is not viewed as the quitter by peers in the OS community, even though his or her engagement in the platform declines due to deterioration in the perception of justice. However, once the specific OS project is completed or reached a certain milestone, they can potentially decide to not come back to participate in future projects hosted by the platform organization. Hence, based on these justifications, we hypothesize that

H1a: The perception of distributive justice of rewards in an open source project will positively influence an IS professional's engagement in the platform organization that hosted the OS project.

H1b: The perception of distributive justice of rewards in an open source project will positively influence an IS professional's intention to participate in the platform's future development activities.

Procedural and distributive justice are very much connected to each other; the latter being focused on the outcome and the former being the focused on the procedures followed to determine the recipient of the outcome. Procedural justice, like distributive justice, are found to be highly correlated with organizational commitment (Colquitt et al. 2013). In the case of open source software development, procedural justice may be even more important. Given that usually there is no direct financial payment involved and rewards are given more in the form of

recognition. While it is arguable that because of the volunteer nature of open source development there is little expectation of identifiable reward among IS professionals. However, if there is indeed some identifiable reward that is given to someone in a project, the IS professionals contributing in the project will expect the procedure for determination and distribution of the reward should be fair even if the reward is deficient compared to their inputs in the project. Procedural justice may even have more relevance to the platform organization than distributive justice because platform organizations are actively involved in helping setup OS projects, marketing the projects, and recruiting open source contributors. For instance, Kaggle encourages people and organizations to host data science competitions on its platform. Once a competition is held and rewards are distributed, it is natural for the participants to assign a share of responsibility to Kaggle to enforce procedures in the competitions hosted in the platform. In other words, if participants feel lack of procedural justice in rewards, they will not only blame the host of specific OS project but also blame the OS platform for not enforcing fairness in procedures and this will surely influence their organization engagement in the platform and their intention to participate in future activities hosted in the platform. Hence, based on these justifications, we hypothesize that

H2a: The perception of procedural justice of rewards in an open source project will positively influence an IS professional's engagement in the platform organization that hosted the OS project.

H2b: The perception of procedural justice of rewards in an open source project will positively influence an IS professional's intention to participate in the platform's future development activities.

Informational justice is very important for decision making (Xue et al. 2011). In the age of information systems and especially for IS professionals, it is expected that information about a potential reward will be communicated fairly among all contributors in OS projects. After all, the open source software development is an information system endeavor and lack of information is not only detrimental to the perception of justice but also simply not professional. There are many ways to communicate to the participants of an OS project. Discussion boards, emails, twitter feeds are only few examples of many avenues that are available for communicating to participants. Moreover, OS platforms usually have community guidelines about how OS projects hosted in the platform should be managed. Hence, if an IS professional sees lack of informational justice in an OS projects s/he can potentially think of two scenarios about the OS platform: a) the platform does not have sufficient guidelines or b) the platform does not enforce its guidelines; both of these scenarios could lead to decrease of engagement in the platform organization and decrease in intention to participate in future platform activities. On the other hand, if an IS professional perceives greater informational justice in an OS project, her engagement in the host platform and his intention for continued participation in the platform's future activities will increase. Hence, based on these justifications, we hypothesize that

H3a: The perception of informational justice of rewards in an open source project will positively influence an IS professional's engagement in the platform organization that hosted the OS project.

H3b: The perception of informational justice of rewards in an open source project will positively influence an IS professional's intention to participate in the platform's future development activities.

RESEARCH METHODOLOGY

Study Design

We conducted our study of perceptions of justice, engagement and participation in open source platform using a cross-section survey design. The survey included established measures from the information systems (e.g., Ho and Rai 2017), organizational justice (e.g., Colquitt 2001), and engagement (e.g., Saks 2006; Rich et al. 2010) literature. The survey was posted in Amazon Mechanical Turk (AMT). While the AMT was used as a marketing tool to reach potential respondents, the survey itself was hosted in the Qualtrics server. AMT directed interested IT professionals to an anonymous link hosted by Qualtrics. Respondents were paid $5 for a fully completed survey. Each respondent who reached the end of the survey was provided a random seven-digit code that s/he would provide to AMT to receive the payment from AMT. The respondents had four hours to complete the survey. The clock would start at the time when a respondent chose to respond in the AMT system and the clock would end at the time when a respondent provided the random code s/he receive from the Qualtrics survey.

The survey on AMT was designed to be marketed to IS professionals. To ensure that the survey was marketed to the right people, we used the AMT category 'Job Function – Information Technology' as a requirement. We included further screening in the survey in addition to AMT's IT professional category. The screening included the following questions: "Are you an information system or technology professional? Are you currently participating or recent participated in one or more open source development of information systems projects?" The questions also included a highlighted note which stated that "A potential participant of this survey must be an information systems or technology professional who is currently contributing or has contributed in one or more open source software development project(s). Hence,

answering NO to this question will terminate the survey." The survey automatically moved to the end for a participant who answered negatively to any of these questions. If a participant indeed answered 'no' to these questions s/he received a note of appreciation and an explanation to the abrupt termination. The note was as follows: "THANK YOU for your time and effort in completing this survey. We sincerely appreciate your contribution to our research. In case you have reached this point only after the first one or two questions, that means you have answered no to any of the first two questions. As we mentioned in our disclosure, a potential participant must be an information systems or information technology professional who is currently participating or has participated in one or more open source software development project(s). Hence, answering NO to these questions have terminated the survey for you. In any event, we appreciate your interest."

Participants

We received a total of 290 responses. These 290 respondents reached the end of the survey and provided the code to AMT to collect their payments. However, only 109 responses were included in the final analysis in this paper. Reponses were excluded from the final analysis for two reasons. First, we excluded the responses in which the respondents mentioned that they did not receive any form of rewards in the open source projects they referred to since we looked at rewards as the object that help develop perception of justice. A total of 53 responses were excluded from the final analysis because of this reason. Second, the responses that did not include answers for the focal variables (perceptions of justice, platform engagement and continued participation intention) or relevant control variables (e.g., gender, age group, OSSD experience, tenure in project) were deemed as incomplete and excluded from the final analysis. We excluded 128 responses because of the incomplete nature of the responses. Hence, were left

with 109 usable responses for our final analysis.

Approximately twenty percent of the respondents were female, and the remaining respondents were male. The highest number of respondents aged between 21 and 30 years (approximately 34%) followed by respondents who aged between 31 and 40 years (approximately 26%). A more detailed demographic data is provided in Table 2. The following table about the demographics indicates that, as per this sample, mostly younger professionals who are early in their career and in their 20s and 30s are involved more heavily in open source development than those who are in their 40s and 50s. The demographic also indicated that there more male IS professionals who contribute in OS projects and/or receive rewards in OS projects compare to female IS professionals.

Table 2: Participants' Demographics

Age Group	Female	Male	Total
Below 20 years	0	2	2
Between 21 and 30 years	11	46	57
Between 31 and 40 years	11	32	43
Between 41 and 50 years	0	6	6
Above 50 years	0	1	1
Total	22	87	109

The respondents had an average of approximately 5 years of work experience in open source development of information systems. The largest number of respondents, 32% reported that they contribute to open source project both for free and for payment. However, 18% reported that they only contribute for free while the remaining 16% contribute only for a payment. The highest number of projects participated by the respondents was 40 while for some IS professionals, the specific project was their first OS project. 90% of the respondents reported to have a full-time job in the domain of proprietary software development. In average, approximately 12 IS professionals contributed in the reported OS projects. The projects in our sample included both voluntary projects (51) that did not involve any payments and paid (58)

projects. A large majority, approximately 34%, of the projects were initiated by a private individual or a group of individuals. 28% projects were initiated by the platform organization, 20% by a non-profit other than the platform, and the remaining projects were initiated by a for-profit organization. Even though the respondents mentioned various open source platforms they prefer to work with, the top 5 favorite platforms included GitHub, Linux, Kaggle, Sourceforge, and Oracle BeehiveOnline. The respondents were involved in a wider variety of open source projects hosted in various OS platforms that are compatible with operating systems such as Linux, windows. The purpose for these projects included but not limited to e-commerce, security enhancement, artificial intelligence, patient data systems, heatmap, internet bot, and crypto currency.

Measures

The focal variables of this study included the three justice perceptions, platform engagement, and intention participate in future platform activities. To measure the constructs in our study, we searched for appropriate and already validated scales in the existing literature. All of the measurement items used in this study were collected from existing literature to operationalize the constructs. We used a 4-item scale for distributive justice, 7-item scale for procedural justice, and 5-item scale for informational justice. All of these items were adapted from Colquitt (2001) with slight modification for the OSSD context. *Platform engagement* was measured using a six-item scale adapted from Saks (2006). In addition to covering the cognitive, emotional, and behavioral aspect of engagement, the items developed by Saks (2006) also specifically focused on organization engagement. We believe because the measurement items focused on organization engagement makes the items more relevant to our study of the platform engagement in the open source environment. Finally, *intention to participate in future platform*

activities was measured using two items adapted from Ho and Rai (2017) who used the items to measure volunteer continued participation intention. The items were unchanged if they fit our context. However, some of the items were slightly modified to fit the context of open source development. For instance, the question "Does your (outcome) reflect the effort you have put into your work?", was modified to "Did your rewards reflect the effort you put into your project?". Participants provided their responses to measurement items for all of the focal constructs using Likert-type scales with anchors (1) strongly disagree to (7) strongly agree. Table 3 includes the measurement items for the focal variables.

Table 3: Measurement items for the focal variables

Distributive Justice The following items refer to your rewards that you received due to your participation in the open source project. To what extent: • Did your rewards reflect the effort you put into your project? • Were your rewards appropriate for the work you completed? • Did your rewards reflect what you contributed to the project? • Were your rewards justified, given your performance?
Procedural Justice The following items refer to the procedures used to arrive at the rewards that you received for your participation in the open source project. To what extent: • Were you able to express your views and feelings during those procedures? • Did you have influence over the rewards arrived at by those procedures? • Were those procedures applied consistently? • Were those procedures free of bias? • Were those procedures based on accurate information? • Were you able to appeal the rewards arrived at by those procedures? • Did those procedures uphold ethical and moral standards?
Informational Justice The following items refer to the project management/leadership who were responsible for determining and distributing rewards for your participation in the open source. To what extent: • Was the project manager or platform candid in his/her communications with you about the rewards? • Did the project manager or platform explain the procedures thoroughly about how the recipient of the reward will be determined? • Were the project manager or platform explanations regarding the procedures reasonable?

Table 3 (Cont.)

Informational Justice (Cont.) • Did the project managers or platform communicate project or competition details in a timely manner? • Did the project manager or platform tailor his/her communications to individuals' specific needs?
Platform Engagement Please rate how engaged you are in the platform organization (the platform name goes here) that is hosting the open source project in question • Being a member of this organization is very captivating. • One of the most exciting things for me is getting involved with things happening in this organization. • I am really not into the "goings-on" in this organization (R). • Being a member of this organization make me come "alive." • Being a member of this organization is exhilarating for me. • I am highly engaged in this organization.
Intention to Participate in Future Platform Activities • I predict I would continue participating in projects hosted in (platform name). • I plan to continue to participate in projects hosted in (platform name).

We included several individual and project related variables in our study to control for alternative explanation. We controlled for individual attributes – gender and age that have been found to be important in various IS and non-IS studies (Anthony-McMann et al. 2017; Ho and Rai 2017; Morris and Venkatesh 2010; Rich et al. 2010; Saks 2006). Gender was coded as a binary code: female or male. The respondents were divided into five age groups: below 20 years, 21 to 30, 31 to 40, 41 to 50, and above 50 years. We also controlled for open source project related attributes which have been identified as important factor in open source literature – project phase, project update, and team size, contribution type (free or paid), experience in OSSD, and tenure in project (e.g., Ho and Rai 2017; Faraj et al. 2015; Setia et al. 2012). Team size was equal to the number of people who have contributed to the project. Tenure in project was measured in number of years in which months were converted into years.

EMPIRICAL ANALYSIS AND RESULTS

Following standard practice, we first tested the reliability and validity of various scales and then test our proposed research model about the influence of justice perceptions in open source software development

Measurement Model Evaluation

To evaluate the measurement model, we tested the reliability and validity of the scales used in our study. For testing the reliability of the measures, we used Cronbach's Alpha. Cronbach Alphas for the focal variables were as follows: distributive justice (0.82), procedural justice (0.76), informational justice (0.79), OS platform engagement (0.84), and intention to participate in the future platform activities (0.72). Given that all of the Cronbach Alphas were 0.72 or above which is higher than the threshold of 0.70, we concluded that all scales were reliable. To assess the convergent and discriminant validity of the survey items a confirmatory factor analysis was conducted on the focal variables using principal components to see if items were loading on the desired variables. Varimax rotation with Kaiser Normalization was used to achieve optimum loading of the items. The rotation converged in six iterations and converged on five factors. The Bartlett's test of sphericity indicates that (Chi-Square =714.14, $p < .005$) the dataset is appropriate for factor analysis (Bartlett 1950). All of the item's communality was above 0.5. The factor analysis show that the average factor loading for all factors were above .70 and average variance extracted were above .50, which according to (Fornell and Larcker 1981), indicated good convergent validity of the scale items. None of the cross-loadings were above indicating good discriminant validity. For measuring sampling adequacy, we used the Kaiser-Meyer-Olkin (KMO) sampling adequacy test. The KMO measure of sampling adequacy was .848 which can be labelled as "meritorious" indicating that we do not need to examine the anti-

image correlation matrix (Kaiser and Rice 1974).The KMO test score of 0.85 which is between 0.8 and 1, according to Kaiser (1974), indicated that the sampling was adequate for the factor analysis. The factor loading of the measurement items for all focal variables are presented Table 4. Finally, we also checked for any common method bias since survey data are prone to such bias (Podsakoff et al. 2003). We conducted Harmon's one-factor test by running an exploratory factor analysis. Since any single factor did not account for the majority of the variance, according to Iyengar et al. (2015), we can conclude that there was no common method bias.

We excluded few measurement items because they did not load properly. We dropped one item for distributive justice: "Were your rewards appropriate for the work you completed?". We believe, while the other items mentioned work in such a way that it appeared synonymous to contribution, this item appeared to give the impression that the work referred to paid job which would not be applicable to the IS professional's contribution to the OS project. We dropped four items (1, 3, 4, and 5) for procedural justice which we believe did not apply to the open source context. For instance, the question, "Were you able to appeal the rewards arrived at by those procedures?" appears to not apply with IS professionals contributing in OS projects. Unlike in the proprietary environment where there is usually an established channel to channel grievance (e.g., human resource), the structures in OS projects are not so well organized and therefore lacks a viable way to appeal. Moreover, since a volunteer can always leave, s/he may not feel fighting irregularities in OS projects. We believe the same logic applied to the items that we dropped for informational justice that those were not applicable to the OS environment. Finally, we dropped two items for platform engagement. One item that stated "I am really not into the "goings-on" in this organization" was a reverse-coded item. Given that many researchers indicate that reverse-coded items tend to give rise to validity issues (Morris and Venkatesh 2010), we believe this

item faced the same problem.

Table 4: Factor Analysis with Varimax Rotation and Kaiser Normalization

	1	2	3	4	5
Distributive Justice 1	**0.77**	0.17	0.26	0.18	0.17
Distributive Justice 3	**0.74**	0.28	0.23	0.25	-0.07
Distributive Justice 4	**0.73**	0.07	0.17	0.34	0.24
Procedural Justice 2	0.08	**0.89**	0.19	0.20	0.13
Procedural Justice 6	0.34	**0.72**	0.21	0.26	-0.12
Informational Justice 1	0.32	0.22	**0.65**	-0.03	0.36
Informational Justice 2	0.11	0.15	**0.83**	0.14	0.10
Informational Justice 5	0.17	0.12	**0.83**	0.26	-0.05
Platform Engagement 1	0.40	0.16	-0.05	**0.72**	0.13
Platform Engagement 2	0.07	0.10	0.26	**0.75**	0.23
Platform Engagement 4	0.12	0.26	0.24	**0.74**	0.05
Platform Engagement 6	0.31	0.10	0.07	**0.79**	0.10
Intention to participate in future Platform activities 1	0.11	-0.03	-0.03	0.18	**0.63**
Intention to participate in future Platform activities 2	0.09	0.03	0.17	0.25	**0.86**

Table 5 includes the descriptive statistics and reliabilities among the variables. The table also includes the means and the standard deviations for the focal and control variables. The mean scores for three justice perceptions were above 5.11 on the scale of 7. The mean score for platform engagement was 5.57 and 5.86 for intention to participate in future platform activities, which were also measured on the scale of 7. The standard deviations for these variables hovered around 1 except procedural justice. The standard deviation for procedural justice scores were 1.44. The descriptive statistics shows that the focal variables (distributive justice, procedural justice, informational justice, intention to participate in future platform activities, and platform engagement) have a higher mean than the center of the scales. Given that this is self-reported data, upward skewness is expected for such variables (Belanger et al. 2001). The upward skewness has been also found in previous literature that studied engagement (e.g., Rich et al. 2010).

Table 5: Descriptive Statistics and Reliabilities

	Gender	Age Group	OSD Exp	Tenure In Project	Contr. Type	Project Phase	Project Update	Team Size	Dist. Justice	Proc. Justice	Info. Justice	Platform Eng.	Intention to Participate
Mean	0.20	2.51	4.67	1.85	0.47	2.12	2.42	8.05	5.59	5.11	5.36	5.57	5.86
Standard Error	0.04	0.06	0.32	0.14	0.05	0.08	0.07	0.60	0.11	0.14	0.11	0.09	0.10
Median	0.00	2.00	4.00	1.33	0.00	2.00	3.00	6.00	6.00	5.00	5.33	5.75	6.00
Mode	0.00	2.00	3.00	1.25	0.00	3.00	3.00	5.00	6.00	6.00	6.00	5.50	7.00
Standard Deviation	0.40	0.68	3.34	1.41	0.50	0.79	0.75	5.89	1.16	1.44	1.16	0.94	0.99
Sample Variance	0.16	0.46	11.16	1.99	0.25	0.62	0.56	34.70	1.35	2.07	1.34	0.88	0.99
Kurtosis	0.27	0.89	6.27	1.60	-2.02	-1.36	-0.56	2.39	1.35	-0.06	0.91	0.38	-0.17
Skewness	1.51	0.78	2.16	1.36	0.13	-0.22	-0.60	1.48	-1.06	-0.70	-0.82	-0.79	-0.74
Range	1.00	4.00	21.00	6.17	1.00	2.00	3.00	31.00	6.00	6.00	6.00	4.50	4.00
Minimum	0.00	1.00	0.00	0.08	0.00	1.00	1.00	1.00	1.00	1.00	1.00	2.50	3.00
Maximum	1.00	5.00	21.00	6.25	1.00	3.00	4.00	32.00	7.00	7.00	7.00	7.00	7.00
Reliabilities	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.82	0.76	0.79	0.84	0.72

Table 6: Correlations

Variables		1	2	3	4	5	6	7	8	9	10	11	12
1	Gender												
2	Age Group	-0.01											
3	OSD Exp	0.00	.49**										
4	Contribution	-.20*	-0.01	-0.05									
5	Pro. Phase	-0.16	.27**	.29**	0.00								
6	Project Update	-.19*	0.15	0.15	-0.11	.211*							
7	Tenure in Project	-0.01	0.13	.33**	-0.14	0.11	0.09						
8	Team Size	.28**	-0.06	0.12	-0.12	-0.03	0.18	0.02					
9	Distributive Justice	0.04	-0.02	.19*	-0.11	0.08	0.08	.24*	.45**				
10	Procedural Justice	0.14	-.24*	0.02	-0.11	-0.08	0.01	.25*	.30**	.46**			
11	Informational Justice	-0.04	-0.12	0.15	-0.10	0.12	0.19	.27**	0.18	.58**	.44**		
12	Platform Engagement	-0.03	-0.10	.20*	-0.06	-0.05	-0.07	.27**	0.17	.58**	.44**	.44**	
13	Intention to Participate in Future Platform Activities	0.03	0.02	0.08	-0.07	0.05	0.14	.23*	.24*	.52**	0.10	.36**	.43**

Note: *p < 0.05; **p < 0.01

The upward skewness indicates that the values are potentially not normally distributed. The skewness and kurtosis also indicate normality issue. Hence, we conducted the Shapiro-Wilk test of Normality, which is an effective test of normality for sample sizes less than 5,000 (Razili and Wah 2011). The Shapiro-Wilk test shows that the scores for the focal variables are indeed not normally distributed since the p-values were found to be less than 0.05. Hence, to mitigate the issue of normality, we transformed the variables by using the log function. The log transformation appeared to change the distribution to a more normal distribution.

Table 6 includes the correlations among the variables after the transformation of the focal variables. Several control variables were found to be slightly correlated with the focal variables and with other control variables. The three justice perceptions were found to be highly correlated to each other which is in line with Colquitt's (2001) findings. It should be noted that all of the three justice perceptions were found to be significantly correlated with platform engagement and intention to participate in future platform activities except procedural justice which was not significantly correlated with the intention. In addition, intention to participate in future and platform engagement were significantly correlated with each other. All of which are simply indicative of potential relationship among justice perceptions, platform engagement and intention to participate in future platform activities.

Theoretical Model Testing

Our research model has two central arguments: perceptions of justice are important in open source projects and these perceptions can influence an IS professional's engagement in the OS platform organization and his or her intention to participate in that platform's future development activities. Based on the nature of our hypotheses, we used ordinary least squares (OLS) to test our research model. We conducted the tests in two phases. We also tested for any

multicollinearity issues using variance inflation factors (VIF) as indicators of multicollinearity issues. The VIF values in all the models that we tested were well below ten, the acceptable threshold (Gruber et al. 2010; Petter et al. 2007), indicating that there was no serious multicollinearity issue.

In the first phase, we tested the effects of perceptions of justice on OS platform engagement. We started with the control variables. No control variables were found to significantly impact IS professional's OS platform engagement. The model explained 15.03% of the variance in OS platform engagement. Once the impacts of the control variables were tested, we added the three justice perceptions in the OLS model. The results show that the two perceptions of justice have strong influence on an IS professional's platform engagement in the open source environment. The model explained 47.92% of the variance in OS platform engagement. The variance explained by the main effects model was significantly (32.89%) higher than the model that included only the control variables. The results predicting OS platform engagement are provided in Table 7. The results show that distributive justice ($B = 0.05$, $p < 0.005$) and procedural justice ($B = 0.0029$, $p < 0.05$), have significant positive influence on an IS professional's engagement in the open source development platform. The findings therefore support hypotheses 1a and 2a. However, the findings did not support 3a even though informational justice seemed to positively influence OS platform engagement.

Table 7: OS Platform Engagement Model Results

	OS Platform Engagement	
	Control Variables	Main Effects
R^2	0.15	0.47
ΔR^2		0.33**
Gender (1= Female)	-0.00	-0.00
Age Group	-0.00	-0.00
OSSD Experience	0.00	0.00
Contribution (1=Free)	-0.00	-0.00
Project Phase	-0.00	-0.00
Project Update	0.0	-0.00
Team Size	0.00	0.00
Tenure in Project	0.00	0.00
Distributive Justice		0.05**
Procedural Justice		0.003**
Informational Justice		0.01

Note: *p < 0.05; **p < 0.01.

In the second phase, we tested the effects of perceptions of justice on IS professional's intention to participate in the OS platform's future activities; we started with the same set of control variables. The control variables model explained 33.31% of the variance in IS professional's continued participation intention. The results show that platform engagement significantly impacts the intention to participate in future platform activities. Once the impacts of the control variables were tested, we added the three justice perceptions in the OLS model. The results show that the distributive justice and procedural justice perceptions have strong influence on an IS professional's intention to participate in future platform activities. We should also note that the influence of platform engagement remains significant even after including the justice perception in the regression model.

The model explained 44.77% of the variance in IS professional's intention to participate in future platform activities. The variance explained by the main effects model was significantly (11.46%) higher than the model that included only the control variables. The results predicting intention to participate in future platform activities are provided in Table 8. The results show that

distributive justice has significant positive influence (B = 0.0233, p < 0.05) on an IS professional's intention to participate in future platform activities. The results also show that procedural justice has significant positive influence (B = 0.0033, p < 0.01) on an IS professional's intention to participate in future platform activities. The findings provide support for hypothesis 1b and 2b. However, given that informational justice was found to have no significant influence, hypotheses 3b was not supported.

Table 8: Results for Intention to Participate in Future Platform Activities

	Intention to Participate in Future Platform Activities	
	Control Variables	Main Effects
R^2	0.33	0.44
ΔR^2		0.11*
Gender (1= Female)	-0.00	0.00
Age Group	0.00	0.00
OSSD Experience	-0.00	0.00
Contribution (1=Free)	0.00	-0.0
Project Phase	0.00	0.00
Project Update	0.00	0.00
Team Size	0.00	-0.00
Tenure in Project	0.00	0.00
Platform Engagement	0.35**	0.27**
Distributive Justice		0.02*
Procedural Justice		0.003
Informational Justice		0.007

Note: *p < 0.05; **p < 0.01.

Robustness test using alternative engagement dimensions and measures

Engagement is a very comprehensive construct that involves the investment of a person's physical, cognitive, and emotional abilities into a work role (Rich et al. 2010). In our study we hypothesized that perceptions of justice will influence an IS professional's organization engagement in the OS platform and his or her intention to participate in future activities hosted by the OS platform. We used platform engagement because we thought it fit the goal of our study well which was to find how justice perception can predict an IS professional's relationship

to an OS platform. An OS platform has all the characteristics of an organization and therefore an organizational point of view is the most appropriate way to assess a relationship between an IS professional and an OS platform. However, we do acknowledge that platform engagement, which we adapted from the concept of organization engagement proposed by Saks (2006), does not explicitly cover the physical, emotional and cognitive dimension of engagement. Some management scholars have conceptualized and developed measurement items that examined the multidimensional nature of engagement. For instance, Soane et al. (2012) developed scales that looked at intellectual, social and affective dimensions, and Rich et al. (2010) developed scales that looked at physical, emotional and cognitive dimensions. We argue that while these scales do not cover the organizational point of view, they are nonetheless good alternative for testing the impact of justice perceptions on IS professional's engagement in the open source software development environment. While both Soane et al. (2012) and Rich et al. (2010), we used the Rich et al. (2010) because their scales not only cover psychological but physical aspects as well. Before we used the Rich et al. (2010) measures, we also conducted tests of reliability and validity of the measures. The Cronbach Alphas for physical engagement, emotional engagement, and cognitive engagement were 0.79, 0.91, and 0.92 accordingly. We also did not find any validity issues with the measures. The measurement items for physical, emotional, and cognitive engagement are listed in appendix A. For the alternative models, we tested the impact of perceptions of justice on all three dimensions of engagement. The results of the alternative models are provided in Table 9.

Table 9: Results for Physical, Emotional, and Cognitive Engagement

	Physical Engagement		Emotional Engagement		Cognitive Engagement	
	Control Variables	Main Effects	Control Variables	Main Effects	Control Variables	Main Effects
Gender (1= Female)	0.18	0.16	-0.09	-0.08	-0.14	-0.13
Age Group	-0.28	-0.10	-0.16	-0.08	-0.30	-0.18
OSSD Experience	0.04	0.03	0.06*	0.05	0.04	0.03
Contribution (1=Free)	-0.32	-0.15	-0.24	-0.07	-0.27	-0.10
Tenure in Project	0.10	0.01	0.07	0.00	0.11	0.03
Team Size	0.01	0.01	0.00	-0.01	0.00	0.00
Distributive Justice		0.13		0.35**		0.23**
Procedural Justice		0.15		0.11		0.11
Informational Justice		0.21**		-0.01		0.08

Note: *p < 0.05; **p < 0.01.

The results are mostly consistent to the findings in the original model proposed in this paper using platform engagement. For instance, we found that distribute justice significantly impacted both emotional engagement and cognitive engagement. This finding is similar to the finding in the testing of the original model where we also found that distributive justice significantly and positively influenced platform engagement of IS professionals in the open source environment. We also found that OSSD experience was significant for emotional engagement while tenure in project was significant for cognitive engagement. These control variables were significant in the models that included only the control variables. However, these variables became insignificant when the justice perceptions were added to the list of predictors in the models.

The results were not all in line with our original model. For instance, procedural justice was not found to be significant for any of the dimension. This is probably the biggest difference between the alternative models and the original model proposed in this study. We believe this difference is a reflection that procedural justice perception is an important factor when it comes an IS professional's engagement in the platform organization. Even though there are nuanced

differences between the findings in the original proposed model and in the alternative models of engagement, the robustness check corroborates our central premise that perceptions of justice are important in the domain of open source software development. The main effects models explained 35.74%, 39.57%, and 39.67% variance in the physical engagement, emotional engagement, and cognitive engagement accordingly. All three main effects models explained significantly higher variance than the models that included only the control variables.

DISCUSSION

Volunteer participation in the open source environment is the key component of the open source innovation model (von Hippel and von Krogh 2003). Lack of long-term voluntary participation causes many open source projects to be abandoned (Fang and Neufeld 2009). Therefore, what factors may influence continued voluntary participation remains a topic of great interest to IS researchers (Ho and Rai 2017; Maruping et al. 2019). The existing IS literature has looked at various factors that lead to continued participation in OS projects (e.g., Ho and Rai 2017; Daniel et al. 2018). These research works were conducted from the project point of view. In other words, these researches looked at why an IS professional will continue to work in an ongoing OS project. However, there is a lack of research that examines the platform point of view. In other words, the research on what factors may lead to IS professional to continue working on projects hosted by the same platforms is not done yet. Our study tries to fill this gap by examining several relationships that will shed more light on the relationship between IS professionals and the OS platforms that host the OSSD projects. Hence, the goal of this study is to investigate the influence of a behavioral aspect, perception of justice, and how that perception may influence IS professionals' engagement in platform organizations and their intention of continued paticipation in those platforms's future activities.

We look at platform as the embodiment of organization from a traditional viewpoint which is capable of authoritative actions that can lead to the development of justice perceptions. We looked at various forms of rewards that are routinely used in the OS projects including monetary rewards that may provide the basis for the development of justice perceptions. Following other scholars who conducted research on justice perceptions, using the social exchange theory, we proposed a middle-range theory (Van de Ven 2007, p.142) in which we examined how perceptions of justice influence an IS professional's engagement in the host OS platform and the continued participation intention in future activities hosted by the platform. We used a survey design to ask participants, who are currently contributing or have recently contributed to open source software development, questions about their perceptions of justice, their engagement in the platform organizations that are hosting the OS projects they are working on, and whether they will contribute in OS projects hosted by the same platform in future. We also looked at personal engagement of IS professionals in the OS projects using measurement items that focused on physical, emotional and cognitive dimensions of engagement. These additional variables provided us the alternative models of engagement for testing the robustness of the influence of justice perceptions on engagement and the overall importance of these perceptions in the OSSD environment.

The results corroborated two of the three hypotheses that are related to predicting platform engagement. As hypothesized, the results show that perception of distributive justice and procedural justice positively influence an IS professional's platform engagement in the open source platforms that hosted the OS project s/he worked on. However, the results did not support our hypothesis that informational justice will positively impact an IS professional's platform engagement. The control variables' model showed that an IS professional's age group

significantly impacts platform engagement, however, when the perceptions of justice were added to the model, the influence of age group became insignificant.

The results also corroborated two of the three hypotheses that are related to predicting the intention of IS professional to participate in future OS projects hosted by the same platform. As hypothesized, the results show that perception of distributive justice and procedural justice positively influence an IS professional's continued participation intention in future platform activities. However, the results did not support our hypotheses that informational justice will also positively impact the continued participation intention. The control variables' model showed that an IS professional's platform engagement significantly impacts his or her intention to participate in future, however, when the perceptions of justice were added to the model, the influence of education became insignificant. Finally, our robustness check with an alternative model also showed that informational justice significantly impacts physical engagement, and distributive justice significantly impacts both emotional and cognitive engagement. Overall, the findings showed that perceptions of justice are important factors to the IS professionals contributing in OSSD.

Theoretical Implications

Our study makes three theoretical contributions. Even though limited, the use of the lens of organizational justice is not entirely new in the behavioral science or business research domains. Justice lens has been used in the management literature to explain job performance (Zhang et al. 2014). It has been used in the logistics literature to explain outsourcing relationships between third-party logistics and users (Hofer et al. 2012). Most importantly, it has been used in the IS literature to explain compliance intention in mandatory IT settings (Xue et al. 2011). Recent research also demonstrates that perception of justice can influence IS project

performance (Bhuiyan and Setia 2017). Evidently, in all instances using the justice constructs have led to a significant additional explanation of the phenomenon in question because it helps understand the social exchange between an employee and the organization. The first contribution of our research is that it enricehs this nascent trend in IS literature that is examining how perception of justice can play an important role in the behavior of IS professionals. In addition, the research applies the concept of justice in the unique domain of open source software development. To the best of our knowledge, this is the first study that examines influence of perceived justice of rewards in the open source environment.

Second, our study enriches the engagement literature by applying the concept of engagement in the field of information systems, and specifically in the open source domain. Scholars in the management and psychology literature (e.g. Kahn 1990; Harter et al. 2002; Saks 2006; Rich et al. 2010; Soane et al. 2012; Anthony-McMann 2017) have found that many individual and organization outcomes are driven by an employee's engagement. We enhance this stream of literature by testing justice perceptions as antecedents of organization engagement. To the best of our knowledge, this is the first study that examines engagement of IS professional in the context of open source software development, especially the concept of organization engagement. In other words, as Whetten (2008) suggested, by applying the concept of organization engagement to an emerging field (open source software development) we make a contribution of the theory to the open source literature.

In our study we not only looked at platform engagement but also examined the impact of justice perceptions on the physical, emotional, cognitive dimensions of engagement by using the measurement items developed by Rich et al. (2010). Hence, by utilizing measurement items developed by both Saks (2006) and Rich et al. (2010) we cover two dominant perspectives of

engagement and thus enrich the engagement literature. In addition, we cover both participation and engagement in the same study. While we did not develop any new measurement items, by including both participation and engagement in our measurement model, our study provides a strong support to the notion that participation and engagement are two distinct constructs.

Managerial Implications

More private and public organizations are relying on OSSD for software development (August et al. 2018). Government organizations such as Data.gov is using OSSD through GitHub (Data.gov 2018). Prominent private software organizations such as Google and Microsoft have joined OSSD (Ho and Rai 2017). The study will provide guidance to organizations that are either exploring or already involved in utilizing the OSSD to accomplish projects needed for the organization. OSI platforms have a high stake in the continued voluntary participation of IS professionals in their innovation activities. Open source platforms such as Kaggle have hosted hundreds of programming competitions that involved hundreds of thousands of dollars. Platforms generates revenue from the innovations that are generated by their contributing members. Hence, there is an incentive for platforms to encourage IS professionals for long-term participation. Our study informs various platform management about how justice perception can influence IS professional's engagement and participation in their platforms. This study demonstrates that in the absence of direct pay or financial contract, perceived justice of rewards can potentially play an important role in IS professionals' participation in innovation activities hosted by platforms. This study also should inform various OS platform managers that developing good procedures and enforcing those procedures, especially procedures that are related to various forms of rewards given to IS professional in OS projects are crucial for the long term relationship between an IS professional and an OS platform.

Limitations and Suggestions for Future Research

Our study is not without limitations; however, we believe these limitations are opportunities for additional future research. First, we did find support for our hypotheses in which we looked at the influence of informational justice on platform engagement and continued participation intention. Given that we surveyed only IS professionals, this is rather counterintuitive. After all, one would assume that IS professionals are more conscious about information and would be disturbed if information about any potential reward is not communicated fairly. The lack of significant impact of informational justice may mean two things. First, it could be very specific to the sample that we have collected. Or, it is possible that communication flows so well in open source software projects that informational justice is a non-issue. Future researchers can investigate more deeply about informational justice and communication of rewards in OS projects to look for a more nuanced answer.

Our results show that age group has a negative impact on an IS professional's platform engagement. Though the significance of age group was not true anymore when the justice perceptions were added to the model, it is nonetheless important to understand the role of age in platform engagement. Our study included the age group as a control variable and does not go beyond asking a participant about the age group s/he belonged. Future research can examine why age group is an important factor for platform engagement.

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APPENDICES

Appendix A: Measures for Physical, Emotional and Cognitive Engagement

Physical Engagement (Rich et al. 2010)

1. I work with intensity on my job.
2. I exert my full effort to my job.
3. I devote a lot of energy to my job.
4. I try my hardest to perform well on my job.
5. I strive as hard as I can to complete my job.
6. I exert a lot of energy on my job.

Emotional Engagement (Rich et al. 2010)

1. I am enthusiastic in my job.
2. I feel energetic at my job.
3. I am interested in my job.
4. I am proud of my job.
5. I feel positive about my job.
6. I am excited about my job.

Cognitive Engagement (Rich et al. 2010)

1. *While I work*, my mind is focused on my job.
2. *While I work*, I pay a lot of attention to my job.
3. *While I work*, I focus a great deal of attention on my job.
4. *While I work*, I am absorbed by my job.
5. *While I work*, I concentrate on my job.
6. *While I work*, I devote a lot of attention to my job.

Essay 3

EXPLORING THE ROLE OF EXTERNAL FEEDBACK IN OPEN SOURCE SOFTWARE DEVELOPMENT

ABSTRACT

Understanding the factors that can influence continued voluntary participation of information systems (IS) professionals in open source development (OSD) projects is of great interest to IS researchers and practitioners because volunteer participation is fundamental to the open source model of software development. Researchers have looked at various motivations, both intrinsic and extrinsic, that can lead to participation in OSD projects. However, the existing research does not include an examination of the relationship between external feedbacks and IS professional's participation. Like many online products, open source (OS) software projects are routinely reviewed and rated by users. Our study looked at how this external feedback from users can influence an IS professional's intention to continue to participate on the specific OSD project voluntarily. Using primary data collected through a cross-sectional survey design from 165 IS professionals, our study examines whether importance of external feedback given by IS professionals increase or decrease continued volunteer participation. By utilizing sample actual feedbacks collected from OS platforms, the study also examines how various characteristics of feedbacks can influence continued participation intention. The findings support the notion that external feedbacks do play an important role in the participation of IS professionals in OS projects. The study also shows that motivations and characters of external feedback interact with each other. Our study contributes to the IS literature by shedding light on a new factor, external feedback, that can lead to participation in OS projects.

Keywords: Open source development, open source software, participation, continued participation, online review, user review, motivation.

INTRODUCTION

Open source development of information systems is a social and technical movement that has undeniably changed how information systems are developed. The dynamics of open source software development is indeed different from our understanding of software development in the proprietary environment where IS professionals are directly paid and under some form of contractual obligation to contribute. Instead the world of open source software development is largely dependent on a vast of number of volunteers, a significant portion of those volunteers are contributing for free. Indeed, the open source movement has contributed significantly to society and continues to attract information system (IS) professionals to volunteer their time, effort, and expertise to develop new IS products that can help themselves and the IS community of users (Lerner and Tirole 2002; Hann et al. 2004; Blanchard and Markus 2004; Roberts et al. 2006; Nambisan and Baron 2010; Maruping et al. 2019).

However, availability of free volunteer IS professionals is not the only reason large and small organizations are interested in OSD. Quality of open source software (OSS) is also another big reason that is influencing business' decision to prefer OSS than proprietary software development (August et al. 2018). No software product is perfect. Like any product, the progress of quality of a software does not end with the first implementation or iteration. It is not only common but also essential to make continuous improvement to software to address technological and user related issues. The continuous improvement of Windows software by Microsoft is a testament to this idea of continuous improvement of software products. Software developed in the OSD environment are not different. IS professionals are at the core of this phenomenon of open source development. Continuous contribution to updating the code is credited for the high quality of OSD software (August et al. 2018). Hence, various aspects that can influence the

engagement of IS professional in the software development in open source (OS) environment remains a topic of great interest to researchers (Ho and Rai 2017). Our research dives deeper into the examination of factors that can lead to continued participation of IS professionals in OS software projects.

Earlier IS research found that participation in the OSD is an outcome of a combination of intrinsic and extrinsic motivations (Hars and Ou 2002; Hertel et al. 2003). Therefore, subsequent research on continued voluntary participation followed the same paradigm. Extrinsic motivations such as peer cognition and status have been found to influence continued voluntary participation in OSD projects (von Hippel and von Krogh 2003). A literature review of studies in OSD led von Krogh et al. (2012) to conclude that social practice mediates the relationship between motivations and continued voluntary participation. Fruitful interaction among developers can also positively influence continued voluntary participations (Xu et al. 2009; Qureshi and Fang 2011). IS professionals sometimes tend to gain economically from their employments in the proprietary environment for their role in OSD projects when the roles are aligned in both environments (Hann et al. 2013). Other studies have found that license choice, enforcement of intellectual rights, and team configurations tend to impact continued participation of volunteers in OSD projects (Ho and Rai 2017). Some studies examined quality of coding of open source projects and how that potentially drives continued participation (e.g., Herter et al. 2003; Baldwin and Clark 2006; Ho and Rai 2017). Table 1 below lists a few notable studies that have looked at the continued voluntary participation of IS professionals in open source projects.

Table 1: Research on voluntary participation in open source software development

Sources	Factors that Influence Participation in OS Projects
Colazo and Fang 2010	Project team configuration
Daniel et al. 2018	Ideology, commitment to company, commitment to OSS community
Fang and Neufeld 2009	Situated learning, identity construction
Hahn et al. 2008	Cohesion cues and status cues based on developer's past collaboration
Hann et al. 2004	Social-psychological functions (normative, values, understanding, career concerns, and ego enhancement)
Hars and Ou 2002	Self-determination, altruism, community identification, future rewards, personal need
Hertel et al. 2003	Valence, instrumentality, self-efficacy, and trust
Ho and Rai 2017	Quality control, type of project, tenure in the project
Lerner and Tirole 2002	Career concern incentive, ego gratification incentive
Maruping et al. 2019	Developer open source values, centrality in communication network, commitment to open source community
Nambisan and Baron 2010	The sense of responsibility to community and company, expectations of self-image and expertise enhancement, identification with community and company
Qureshi and Fang 2011	Social interactions between core and peripheral volunteers
Stewart et al. 2006	Open source software licensing choices
von Hippel and von Krogh 2003	Private-collective model of innovation (Private rewards)
von Krogh et al. 2012	Motivations and social practice
Xu et al. 2009	Developer-to-developer interaction

Among the studies on intrinsic and extrinsic motivations, some have noted the importance of feedback on participation. For instance, Hars a Ou (2002) noted that feedback is a very useful way for developers to see "how others are using their contributions." They argue that "the feedback mechanism is self-reinforcing, for it encourages the author to expend additional effort to perfect his code, which in turn attracts more favorable feedback" (Hars and Ou 2002, p. 30). A similar argument was made by von Krogh et al. (2012) that "OSS developers often receive immediate user feedback on installing, systems compatibility, bugs … when developers

see how the software product performs on their own and other users' computers, or compares in efficiency with competing products, they may choose to maintain or adjust the standards of excellence in the social practice, as part of learning to practice better" (p.667). While the literature alluded to the importance of feedback, we are yet to see a nuanced understanding of how external feedback play a role in motivating IS professionals to continue to participate in OS software projects. We address this gap in the open source literature.

External feedback generated by users has been tremendously helpful in the word of e-commerce. Online reviews are the most prevalent form of external feedback that are available in today's world of online market. "Online product reviews help consumers infer product quality, and the mean (average) rating is often used as a proxy for product quality" (Hu et al. 2017, p. 449). The online reviews are becoming increasingly popular to the point that online reviews influence more than two third of online shopping and therefore, organizations are putting more and more emphasis in building or maintaining good online review systems (Shen et al. 2015). While open source software is not quite comparable to online consumer goods, the open source development platforms are allowing users to rate and leave feedbacks on open source projects. Figure 1 shows that OS projects not only keep a history of reviews provided by the users, they even create a cumulative user rating of many OS projects based on the feedback they received from users and highlight some reviews as featured reviews. Because the existing OS literature has not examined the role of external feedback in the development of open source projects, even though many OS project users are actively providing feedbacks, we do not know how these feedbacks contribute to the development of such OS projects.

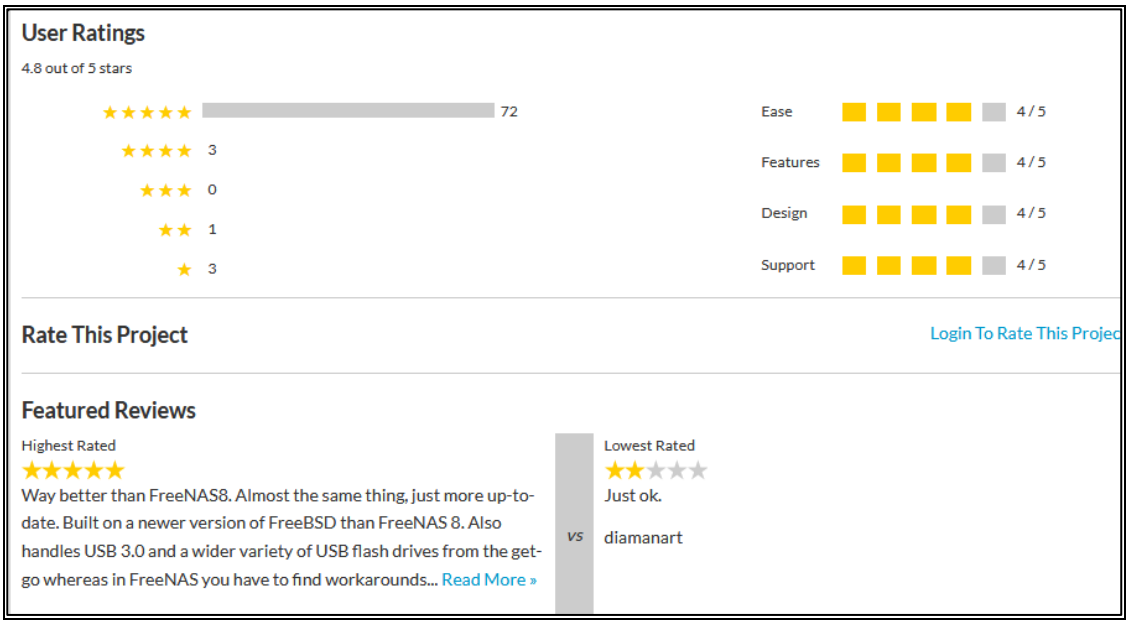

Figure 1: Sample cumulative user-generated ratings of a project in Sourceforge[7]

Our study explores the role of external feedbacks in the open source software development by answering the primary research question: *How external feedback influence continued participation in OS software projects?* We use the signaling theory to guide our examination of the influence of external feedback on the voluntary participation. The signaling theory involves two parties, the signaler and the receiver, in which the signaler shares information that is not known to the receiver in an effort to bring symmetry of information between both parties (Boulding and Kirmani 1993; Connelly et al. 2011; Ho and Rai 2017). Signaling theory provides a framework that helps us understand how external feedback provided by users may influence IS professionals' intention to continue participating in further development of OS projects.

We used a survey study design to ask IS professionals working on various types of OS software projects that served educational, gaming, communication and several other industries

[7] https://sourceforge.net/

that whether they feel external feedback is important to them and used their responses to examine how importance of feedback can influence continued participation. The host platforms for the projects included but not limited to well-known OSD platform such as GitHub, Sourceforge, and Linux. A total of 165 IS professionals' responses were included in our final analysis. The respondents' roles ranged from peripheral developer to core member. The results are supportive of the central assertion that external feedbacks play an important role in driving continued participation intention of IS professionals in the OS software development. Our study enhances the IS literature, especially the research stream focused on OS software development, by highlighting the importance of external feedbacks as a factor that influences participation in OS projects. Continued participation in OS projects have been focus of IS researchers and our study shows that external feedback can play a significant role in influencing continued participation intention even when considered along with other well studied factors such as motivation, a host of project attributes and personal attributes such as education and experience.

THEORY

We design this section in three subsections; we start by defining the constructs. The core sets of the constructs in our research model include importance of feedback, volume of external feedback, valence of external feedback, and continued participation intention. Second, we propose our research model and conclude with our justifications of the hypotheses in our research model.

Construct Definitions

Continued participation intention refers to the intention of developers to participate in an ongoing OS project for further enhancements. Continued participation intention adapted from Ho and Rai (2017) who examined various project attributes (e.g., quality control) as antecedents of

intention to continue participating in ongoing OS projects. Continued participation intention should be distinguished from an IS professional's intention to participate in an OS project the first time. Even though there are potential overlap of factors that can lead to initial participation and continued participation, we are focusing on the IS professionals' intention to continue participating after they have had some exposure to the details of the OS projects.

We refer to external feedback as the feedback that is received from users of an OS software. The users may or may not be a contributor to the software project. The external feedback is provided from a user's perspective not through the channel of communication that contributors (e.g., developers, initiators) would usually use for collaborative purposes. The external feedback would be usually provided by users via a system dedicated for providing user feedback (e.g., online review systems). We examine two characteristics of external feedbacks in our study: volume and valence. Volume and valence have found to be the most prevalent characteristics of online reviews in the existing literature (e.g., Chen et al. 2019; Sahoo et al. 2018; Archak et al. 2011). We refer to *volume of external feedback* as the amount of text written by the user in a feedback. While many researchers of online reviews defined volume as the total number of feedbacks received by a product (e.g., Archak et al. 2011; Sahoo et al. 2018), because we focused on understanding how volume would impact continued participation intention, our definition of volume of external feedback connected to volume of single feedbacks and not to the total number of feedbacks received by an OS project. We refer to valence *of external feedback* as the positive or negative feedback provided by the user. In other words, when the feedback describes an OS project negatively, then we can say that the feedback has negative valence.

Research Model

The key components of the signaling theory includes the signaler, the signal, the receiver, and the feedback sent to the signaler (Connelly et al. 2011). We take guidance from the signaling theory to examine the impact of external feedback in the context of OS projects in which we argue that the users are the signaler, the external feedback is the signal, the IS professionals contributing to the project are receivers, and continued participation in the OS project is a form of feedback sent back to the signalers. The signaling theory suggests that when an asymmetry of information arises when the signaler compels to send a signal to the receiver, the receiver then interprets the merit of the signal and provides a feedback to the signaler. Based on the logical flow of signaling theory, we propose that characteristics of external feedback (e.g., volume and valence) will generate a response from OSD developers in the form of continued participation. Our proposed research model has two segments; a base model and a feedback model. The base model includes various OS project attributes (e.g., owners, users, innovativeness), personal attributes (e.g., education, IS experience, OSD experience, tenure in the OS project) of IS professionals, and intrinsic and extrinsic motivations. The feedback model includes the effect characteristics of external feedback. Figure 2 depicts our proposed research model.

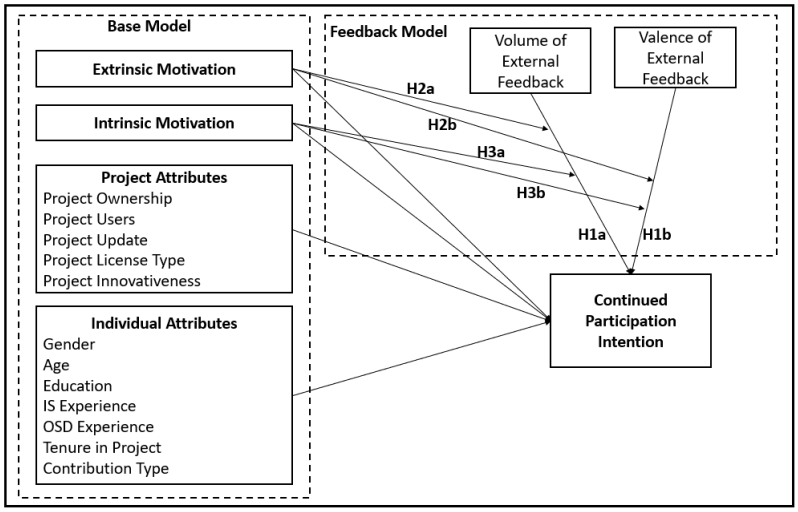

Figure 2: Proposed Research Model

Hypotheses Development

Characteristics of External Feedback

Signaling theory researchers suggest that there are two types of signals: implicit and explicit signals. Most signals are explicit in which the signaler is intentionally trying to reach the receiver's attention about a product that should be of mutual interest (Ho and Rai 2017). We argue that external feedback is a form of explicit signal where the user is trying to reach the developers/project leaders to inform about the potential shortcomings about the OSD project. On the other hand, project's quality control is assumed to be implicit signals. As Ho and Rai (2017) notes that quality control is usually set for producing high quality projects but not necessarily meant for signaling volunteers. Hence, it is arguable that the external feedback is the stronger type of signal for volunteers since it is explicit and meant for the developers. Signaling researchers have emphasized on the quality of the signal as an important factor for the receiver to act on the signal. While naming it in several different ways such as observability, intensity, strength, clarity, visibility (Lampel and Shamsie 2000; Warner et al. 2006; Ramaswami et al. 2010; Connelly et al. 2011), all signaling researchers have acknowledged that a high quality signal will have a better chance of reaching and receiving a feedback from the receiver. We argue that volume can represent high quality for external feedback given that higher volume takes longer to write and provides more details about an OS project. Hence, we hypothesize that

H1a: Higher volume of externa feedback will positively increase an IS professional's intention to continue participating in further development of an open source project.

When an external user uses an OSD project, the user can potentially run into at least two scenarios. First, the user finds the OSD project helpful but lacking in some areas. Second, the user finds the OSD project not up to serving the purpose of the project. In each scenario, an

information asymmetry arises. In the first scenario, even though the primary goals were achieved but the user finds more areas of improvement that may not have been known by the developers. In the second scenario, there is even more asymmetry. Surely, the developer(s) thought the product was ready to function as intended but user finds it either not performing the intended function or critically confounded by other problems that are stopping the project to perform its function. This asymmetry leads the OSD project user to send a signal to the project developers in the form of reviews and ratings. Following the signaling logic, the OSD project developers will interpret the signal (reviews) and send feedback by participating in improving the project. However, IS professionals are humans and therefore it is natural for an IS professional to react positively when they see a positive review (positive valence) even though the feedback may point out to a potential problem (e.g., a bug fix request) or request for an additional feature. On the other hand, if the user review has negative undertone (e.g., criticizes the OS project outright), the IS professional will be discouraged by the feedback and consequentially not participate in the OS project's further development. Hence, we hypothesize that

H1b: Valence of external feedback will have a positive relationship with continued participation intention of IS professionals in OS projects.

Interaction between Characters of External Feedback and Motivations

Intrinsic and extrinsic motivations very different from each other. "The most basic distinction is between intrinsic motivation, which refers to doing something because it is inherently interesting or enjoyable, and extrinsic motivation, which refers to doing something because it leads to a separable outcome" (Ryan and Deci 2000, p. 55). If we follow this distinction, we see that external feedback has elements of both intrinsic and extrinsic motivation. "Extrinsic motivation stems from the environment external to the task and is usually applied by

someone other than the person being motivated" (Roberts et al. 2000, p. 985), and since external feedback is indeed provided by someone other than the IS professional in question, it is arguable that the importance given to external feedback by an IS professional is influenced by that person's extrinsic motivation. In other words, if an IS professional is driven by extrinsic motivation, the need to receive something from others in return for his or her contribution to the OS project, s/he will give higher importance to external feedback. Therefore, the higher level of extrinsic motivation will increase the impact of the characteristics of external feedbacks on an IS professional's continued participation intention. Based on this argument we hypothesize that

H2a: The effect of volume of external feedback on continued participation intention will be positively moderated by the level of extrinsic motivation such that higher level of intrinsic motivation will increase the impact of volume.

H2b: The effect of valence of external feedback on continued participation intention will be positively moderated by the level of extrinsic motivation such that higher level of intrinsic motivation will increase the impact of valence.

In addition, an IS professional, driven by intrinsic motivation, would be interested in contributing voluntarily in an OS project that is important to the OS community to fulfil the need for competence, control, and autonomy as suggested by Ryan and Deci (2000). User feedback can help establish the importance of the OS project to the OS community. "Satisfaction of seeing the results" indicates the level of intrinsic motivation (Robert et al. 2006). External feedback from users is a form of result that shows how efficient or effective an OS project is. Hence, we argue that intrinsic motivation of an IS professional will influence how much importance s/he gives to external feedback in an OS project. In other words, higher level of intrinsic motivation

will increase the impact of the characteristics of external feedbacks on an IS professional's continued participation intention. Based on this argument we hypothesize that

H3a: The effect of volume of external feedback on continued participation intention will be positively moderated by the level of intrinsic motivation such that higher level of intrinsic motivation will increase the impact of volume.

H3b: The effect of valence of external feedback on continued participation intention will be positively moderated by the level of intrinsic motivation such that higher level of intrinsic motivation will increase the impact of valence

RESEARCH METHODOLOGY

Study Design

We conducted our study of external feedback using a cross-section survey design in which we asked respondents about the importance of external feedback and how they would react in terms of continued voluntary participation based on the external feedbacks the project may receive. The survey included established measures from the information systems and open source development literature and measures developed by the authors. The measures are discussed later in this chapter. However, since the sample feedbacks are intricately connected to the study design, they feedbacks are discussed in the following paragraph.

As hypothesized, we planned to test how continued participation intention was influenced based on the feedback received by the project from users. We believe real feedbacks are best to test such impact. Hence, we selected four sample user feedbacks from sourcforge.net. The four sample feedbacks were selected from a pool of 200 feedbacks collected randomly from sourforge.net. Feedbacks with less than 25 words were identified as low volume feedback and feedbacks above 50 words were identified as high-volume feedback. The four feedbacks were

selected in a way so that at least one sample feedback represents each quadrant in the 2x2 design of volume and valence of feedbacks. The sample feedbacks are provided in Table 2.

Table 2: Feedbacks used in our study

Valence	**Volume**	
	High	Low
Positive	Sample 3: Our College uses this software from the much hated flash it campus. The software is great and extensive, but more could be put into easier and flowing designs. Most teachers/lecturers don't have a clue how to use the software sticking work in places they cant find and not knowing how to make an assignment enrolment. But the pros far out way the cons and as seen in my college is vastly used by colleges in the UK at least."	Sample1: Awesome job, thanks a lot for showing
Negative	Sample 2: "this is one of the most non-intuitive non user-friendly software I have EVER used. IF you have a programmer that can work with the teaching staff, you MIGHT be able to use the features that it has... ex. I want to link to a file on my pc. I must upload the file and then CHOOSE it from a list? Well DUH, I want to use the one I just uploaded! Basic web mail apps are smarter than this!!"	Sample 4: Not allowing asynch. Synchronization is weak. Asynch check box grayed out

The survey was administered in four waves. Each wave included a separate a feedback sample in the questionnaire. The respondents were prompted with the text: "Let's say the project received the following summary feedback from users." The respondent was then showed one of the four sample feedbacks. After the respondent finished reading the sample feedback, they were prompted with two sets of manipulation checks. First the respondents were asked to verify whether s/he has read the sample feedback with the text: I have read the above sample feedback shown above (Y/N). The respondents were then asked four additional questions to check whether they agreed with the categorization of the sample feedbacks. The questions are listed in Table 3.

Table 3: Manipulation Check Questions

Questions	Response
I have read the above sample feedback shown above.	Yes or No
Do you think the sample feedback that you have just read is a Long feedback?	Yes or No
Is it a Negative feedback?	Yes or No
Is the Volume of the feedback High?	Yes or No
Is the Valence of the feedback Negative?	Yes or No

Once the manipulation check questions were asked, they were prompted with another text saying, "if most of the feedbacks you have received on the project are similar to the feedback above, we would like to know how these feedbacks would your influence your intention to participate in further development of this project." The respondents were then asked about their intentions to continue participating in the project with a two-item scale.

The survey was posted in Amazon Mechanical Turk (AMT). While the AMT was used as a marketing tool to reach potential respondents, the survey itself was hosted in the Qualtrics server. AMT directed interested IT professionals to an anonymous link hosted by Qualtrics. Respondents were paid $5 for a fully completed survey. Each respondent who reached the end of the survey was provided a random seven-digit code that s/he would provide to AMT to receive the payment from AMT. The respondents had four hours to complete the survey. The clock would start at the time when a respondent chose to respond in the AMT system and the clock would end at the time when a respondent provided the random code s/he receive from the Qualtrics survey.

The survey on AMT was designed to be marketed to IS professionals. To ensure that the survey was marketed to the right people, we used the AMT category 'Job Function – Information Technology' as a requirement. We included further screening in the survey in addition to AMT's IT professional category. The screening included the following questions: "Are you an information system or technology professional? Are you currently participating or recent

participated in one or more open source development of information systems projects?" The questions also included a highlighted note that "A potential participant of this survey must be an information systems or technology professional who is currently contributing or has contributed in one or more open source software development project(s). Hence, answering NO to this question will terminate the survey." The survey automatically moved to the end for a participant who answered negatively to any of these questions. If a participant indeed answered 'no' to these questions s/he received a note of appreciation and an explanation to the abrupt termination. The note was as follows: "THANK YOU for your time and effort in completing this survey. We sincerely appreciate your contribution to our research. In case you have reached this point only after the first one or two questions, that means you have answered no to any of the first two questions. As we mentioned in our disclosure, a potential participant must be an information systems or information technology professional who is currently participating or has participated in one or more open source software development project(s). Hence, answering NO to these questions have terminated the survey for you. In any event, we appreciate your interest."

Participants

We received 50 responses for each wave. Overall, we received a total of 200 responses. These 200 respondents reached the end of the survey and provided the code to AMT to collect their payments. However, only 133 responses were included in the final analysis in this paper. Reponses were excluded from the final analysis for three reasons: partial answers, lack of useful details, and due to manipulation check. First, the responses that did not include answers for the focal variables (e.g., importance of feedback, intrinsic and extrinsic motivation) were deemed as incomplete and excluded from the analysis. Most of the responses that were excluded fell into this first category. Second, responses that appeared to provide vague, unrelated, or meaningless

answers were deemed as answers that lack useful details. Since these responses failed to provide a good description of the open source project, we did not think they are reliable enough for our study. Finally, we excluded 6 responses because they chose 'No' to the manipulation check question that asked whether they read the sample feedback. We received 35 responses for the first wave, 31 for the second, 35 for the third, and 32 for the fourth wave.

Approximately twenty one percent of the respondents were female, and the remaining respondents were male. The highest number of respondents aged between 31 and 40 years (approximately 42%) followed by respondents who aged between 21 and 30 years (approximately 41%). A more detailed demographic data is provided in Table 4. The following table about the demographics indicates that, as per this sample, mostly younger professionals who are early in their career and in their 20s and 30s are involved more heavily in open source development than those who are in their 40s and 50s.

Table 4: Participants' Demographics

Age Group	Female	Male	Total
Below 20 years	0	0	0
Between 21 and 30 years	15	40	55
Between 31 and 40 years	9	48	57
Between 41 and 50 years	5	11	16
Above 50 years	0	5	5
Total	29	104	133

The respondents had an average of approximately 7 years of experience in development of information systems and approximately 2 years of work experience in open source development of information systems. 39% respondents reported that they contribute to open source project both for free and for payment. However, 47% reported that they only contribute for free while the remaining 13% contribute only for a payment. The projects in our sample included both voluntary projects (102) that did not involve any payments and paid (31) projects. A large majority, approximately 48%, of the projects were initiated by a private individual or a

group of individuals. 17% projects were initiated by the platform organization, another 17% by a non-profit other than the platform, and the remaining projects were initiated by a for-profit organization. 22 out of the 133 projects were designed for the education, 11 for gaming, 19 for communication, 30 for utilities and the rest did not fall in the four categories listed above. Even though the respondents mentioned various open source platforms they prefer to work with, the top 5 favorite platforms included GitHub, Linux, Kaggle, Sourceforge, and Oracle BeehiveOnline. The respondents were involved in a wider variety of open source projects hosted in various OS platforms that are compatible with operating systems such as Linux, windows. The purpose for these projects included but not limited to e-commerce, security enhancement, artificial intelligence, heatmap, internet bot, and crypto currency.

Measures

The variables of this study are divided into two main groups. As depicted in our research model, the base model included project attributes, individual attributes, and motivations. The project attributes included project license type, project ownership, project users, project innovativeness, and project update. License type was adopted from Lerner and Tirole (2005). We included four choices: Berkeley Software Definition License, General Public License, Lesser General Public License and Other Licenses. Project ownership was adopted from open source project type (Ho and Rai 2017) which we categorized into four types: a private individual or a group of individuals, an OS platform organization (e.g., Linux), a non-profit organization other than the OS platform organization, a for-profit organization other than the OS platform organization whose ultimate goal is to produce a commercial software. Project users was adapted from Setia et al. (2012) but we categorized the intended project users into three: developers, end-users other than developers and both. Innovativeness was categorized as innovative (the products

uses new technology, a new platform, or is a new application of existing technology) and not innovative (the product uses new technology in an existing market). Project update included information about the nature of update. Ho and Rai (2017) and Setia et al. (2012) alluded to bug fixing as type of update to an open source project. We identified bug fixing as different type of update than adding a new feature to an open source project. Our study included four choices: bug fixes / new features / both / not applicable because were working on the initial release.

Individual attributes included gender, age, education, IS experience, OSD experience, tenure in project, that have been found to be important in many studies in the open source literature, and intrinsic and extrinsic motivations that have been found to be antecedents participation in OS project in the OS literature (e.g., Ho and Rai 2017; Setia et al. 2012; Roberts et al. 2006). Gender was coded as a binary code: female or male. Education was measured in years of formal education. The respondents were divided into five age groups: below 20 years, 21 to 30, 31 to 40, 41 to 50, and above 50 years. IS experience, OSD experience, and tenure in project was measured in number of years in which months were converted into years. We also controlled for contribution type which was coded as a binary variable using free = 1 and paid = 0. The measures for intrinsic motivation and extrinsic motivation were adapted from Roberts et al. (2006). Both types of motivation were measured using four-item scales.

Feedback model included the characteristics of external feedback. Volume of external feedback was coded as high (1) and low (0). Valence of external feedback was coded as positive (1) and negative (0). Finally, Continued participation intention was measured with a three-item scale adapted from Ho and Rai (2017). Even though Ho and Rai (2017) used a two-item scale, we included an additional item to the scale. Participants provided their responses to measurement items for intrinsic motivation, extrinsic motivation, and continued participation intention using

Likert-type scales with anchors (1) strongly disagree to (7) strongly agree. The measures for intrinsic motivation, extrinsic motivation, and continued participation intention are listed in Table 5.

Table 5: Measurement Items

Intrinsic Motivation • It is the satisfaction of seeing the results. • It gives me the chance to do things I am good at. • I really enjoy it. It is fun. • It gives me a sense of personal achievement.
Extrinsic Motivation • It gives me the chance to attain a recognized qualification or skill. • It gives me status at work. • It increases my opportunities for a better job. • It gives me status in the open source community.
Continued Participation Intention • I predict I would continue this project with my codevelopers. • I plan to continue this project with my codevelopers. • I think I will continue to work on further developments of this project

EMPIRICAL ANALYSIS AND RESULTS

Following standard practice, we first tested the reliability and validity of various scales and then test our proposed research model using the data collected about the open source development projects. To evaluate the measurement model, we tested the reliability and validity of the scales used in our study. For testing the reliability of the measures, we used Cronbach's Alpha. The Cronbach Alphas for intrinsic motivation, extrinsic motivation, and continued participation were 0.840, 0.868, and 0.883 accordingly. Given that all of the Cronbach Alphas were above 0.7 of acceptable threshold, we concluded that all scales were reliable.

To assess the convergent and discriminant validity of the survey items a confirmatory factor analysis was conducted on the focal variables using principal components to see if items were loading on the desired variables. Because of low factor loadings and high cross loadings, we excluded one item for extrinsic motivation (it gives me the chance to attain a recognized

qualification or skill). Since IS professionals are able to use a various set of programming or other knowledge to contribute and enhance an open source project, we believe the idea of recognized qualification did not resonate with the respondents.

Table 6: Factor Analysis with Varimax Rotation and Kaiser Normalization

	1	3	2
Intrinsic Motivation 1	**0.76**	0.09	0.31
Intrinsic Motivation 2	**0.79**	0.10	0.32
Intrinsic Motivation 3	**0.75**	0.14	0.19
Intrinsic Motivation 4	**0.87**	0.15	0.24
Extrinsic Motivation 2	0.14	**0.85**	0.16
Extrinsic Motivation 3	0.35	**0.73**	0.07
Extrinsic Motivation 4	-0.04	**0.84**	0.03
Continued Participation Intention 1	0.28	0.04	**0.88**
Continued Participation Intention 2	0.30	0.13	**0.86**
Continued Participation Intention 3	0.29	0.14	**0.87**

The factor loading of the measurement items for all focal variables are presented in Table 6. Varimax rotation with Kaiser Normalization was used to achieve optimum loading of the items. The rotation converged in five iterations and converged on three factors. The Kaiser-Meyer-Olikin measure of sampling adequacy was .817 which can be labelled as "meritorious" indicating that we do not need to examine the anti-image correlation matrix (Kaiser and Rice 1974). The Bartlett's test of sphericity indicates that (Chi-Square =, $p < .005$) the dataset is appropriate for factor analysis (Bartlett 1950). All of the item's communality was above 0.5. The factor analysis show that the average factor loading for all factors were above .70 and average variance extracted were above .50, which according to (Fornell and Larcker 1981), indicated good convergent validity of the scale items. All of the cross-loadings were below 0.5 indicating good discriminant validity. For measuring sampling adequacy, we used the Kaiser-Meyer-Olkin (KMO) sampling adequacy test. The KMO test score of 0.83 which is between 0.8 and 1indicated, according to Kaiser (1974), that the sampling was adequate for the factor

analysis. Finally, we also checked for any common method bias since survey data are prone to such bias (Podsakoff et al. 2003). We conducted Harmon's one-factor test by running an exploratory factor analysis. Since any single factor did not account for the majority of the variance, according to Iyengar et al. (2015), we can conclude that there was no common method bias.

Table 7: Descriptive Statistics and Reliabilities

	Mean	SE	Median	Mode	SD	Kurtosis	Skewness	Min	Max	Reliabilities
Project Ownership	1.97	0.10	1.00	1.00	1.15	-1.01	0.72	1.00	4.00	N/A
Project Users	2.20	0.07	2.00	3.00	0.80	-1.32	-0.38	1.00	3.00	N/A
Project Update	2.44	0.08	3.00	3.00	0.92	-0.87	-0.20	1.00	4.00	N/A
Project License Type	2.68	0.11	2.00	2.00	1.23	-0.36	1.06	1.00	5.00	N/A
Project Innovativeness	1.59	0.04	2.00	2.00	0.49	-1.88	-0.39	1.00	2.00	N/A
Gender	0.22	0.04	0.00	0.00	0.41	-0.09	1.38	0.00	1.00	N/A
Age Group	2.76	0.07	3.00	3.00	0.78	0.31	0.84	2.00	5.00	N/A
Education	15.83	0.15	16.00	16.00	1.70	0.07	-0.64	12.00	19.00	N/A
IS Experience	7.36	0.42	6.00	5.00	4.05	-0.82	0.50	1.00	15.00	N/A
OSD Experience	4.13	0.22	3.00	3.00	2.48	0.12	0.94	1.00	10.00	N/A
Tenure in Project	1.53	0.10	1.25	1.17	1.06	-0.27	0.66	0.08	4.25	N/A
Contribution Type	0.77	0.04	1.00	1.00	0.42	-0.37	-1.28	0.00	1.00	N/A
Intrinsic Motivation	5.13	0.12	5.33	6.00	1.35	-0.13	-0.65	1.00	7.00	0.76
Extrinsic Motivation	5.91	0.08	6.00	6.00	0.95	1.23	-1.18	2.75	7.00	0.87
Continued Participation Intention	5.54	0.11	6.00	6.00	1.23	0.36	-0.91	2.00	7.00	0.92

Table 7 includes the descriptive statistics of the variables after the factor analysis as well as the reliability measures for applicable variables. The descriptive statistics shows that the focal variables (intrinsic motivation, extrinsic motivation, and continued participation intention) have a higher mean than the center of the scales. Given that this is self-reported data, upward skewness is expected for such variables (Belanger et al. 2001). The upward skewness has been also found in previous literature that studied engagement (e.g., Rich et al. 2010). The upward skewness

indicates that the values are potentially not normally distributed. The skewness and kurtosis also indicate normality issue. Hence, we conducted the Shapiro-Wilk test of Normality, which is an effective test of normality for sample sizes less than 5,000 (Razili and Wah 2011). The Shapiro-Wilk test shows that the scores for the focal variables are indeed not normally distributed since the p-values were found to be less than 0.05. Hence, to mitigate the issue of normality, we transformed the variables by using the log function. The log transformation appeared to change the distribution to a more normal distribution.

Table 8 includes the correlations among the variables after the transformation of the focal variables. The correlations, provided in Table 8, show that some of the variables in the base model are correlated with each other. For instance, IS experience and OSD experience are positively correlated with age group. The dependent variable is significantly correlated with contribution type, volume, valance, intrinsic and extrinsic motivations. These correlations among the focal variables are simply indicative of potential relationships among the variables and thus indicative of the importance studying these relationships.

Theoretical Model Testing

Our research model includes a base model and the feedback model. The base model includes a set of project attributes, a set of individual attributes, and motivations that may potentially influence for an IS professional's intention to continue to participate in an OS project. The feedback model builds on the base model to explore whether external feedback can potentially influence continued participation intention. Based on the nature of our hypotheses, we used ordinary least squares (OLS) to test our research model. We also tested for any multicollinearity issues using variance inflation factors (VIF).

Table 8: Correlations

Variables		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Project Ownership																
2	Project Users	0.16															
3	Project Update	-0.12	0.05														
4	Project License	-0.06	0.10	0.04													
5	Project Innovativeness	.30**	0.15	-0.04	-0.11												
6	Gender (Female = 1)	-0.12	-0.04	0.03	0.01	0.10											
7	Age Group	-0.05	-0.01	0.09	-0.02	-.26**	-0.07										
8	Education	0.14	0.15	0.14	0.16	0.02	-0.01	0.17									
9	IS Experience	-0.17	0.07	0.09	-0.08	-.31**	0.03	.56**	0.15								
10	OSD Experience	0.11	0.01	-0.16	-0.04	-0.05	-0.02	.29**	0.13	.39**							
11	Tenure in Project	0.01	-0.12	-0.01	0.06	0.05	-0.07	0.04	0.02	0.03	0.10						
12	Contribution Type	-0.05	0.07	0.03	-0.13	0.05	-0.05	-0.08	0.05	0.01	-0.07	0.01					
13	Volume of Sample Feedback	-0.03	0.09	-0.01	-0.13	-0.04	-0.05	0.04	-.39**	0.07	0.06	0.02	0.08				
14	Valance of Sample Feedback	-0.03	-0.04	-0.07	-0.15	-0.05	0.06	-0.06	-0.06	-0.19	-0.17	-0.11	-0.13	0.01			
15	Extrinsic Motivation	0.08	-0.13	0.16	0.04	.19*	.25**	-.21*	0.07	-0.12	-0.05	-0.09	-0.06	-0.11	-0.03		
16	Intrinsic Motivation	-0.01	0.00	-0.11	0.02	-0.01	0.02	0.09	.24**	0.15	0.11	-0.11	-0.03	-.21*	0.02	.32**	
17	Continued Participation Intention	0.07	-0.05	-0.09	0.10	-0.01	0.07	0.10	0.10	-0.02	0.16	-0.02	-.20*	-.19*	.21*	.24**	.59**

Note: *p < 0.05; **p < 0.01

The VIF values in all the models that we tested were well below ten, the acceptable threshold (Gruber et al. 2010; Petter et al. 2007), indicating that there was no serious multicollinearity issue. We conducted the OLS tests in three phases; first we tested the base model and then we included the feedback model's main effects in the OLS regression analysis, and finally we tested the interaction effects. For the interaction effects, we used a split model analysis. However, before we conducted our regression analysis, we tested to ensure that our manipulation by the sample feedbacks (volume and valance) worked. We used t-test to compare the responses with our categorization. Our tests showed that the p-values were > 0.05 which meant that the means were the same since we cannot reject the null hypothesis. So, we concluded that the manipulations using the sample feedback worked as intended.

During the first regression run that included the base model variables, we found that two project attributes significantly impact continued participation intention of IS professionals. We found that project users ($B = 0.0001$, $p < 0.05$) and innovativeness ($B = 0.0000341$, $p < 0.01$), have significant positive influence on an IS professional's intention to continue to participate in an open source project. This result showed that when a project is intended for multiple users in addition to the developers, they IS professional's intention to continue participating in the project goes down. The result also showed that there is a positive relationship between innovativeness and continued participation intention. This relationship underlines that IS professionals are more interested in projects that are deemed innovative. We did not find any individual attribute to have significant influence on continued participation intention. Finally, we found that both intrinsic and extrinsic motivations significantly influence continued participation intention. Both intrinsic motivation ($B = 0.29$, $p < 0.01$) and extrinsic motivation ($B = 0.032$, $p < 0.05$) positively impacts continued participation intention. This finding is in line with findings in the existing literature

that showed that motivations are important factors for participation in the open source environment. The regression results are provided in the Table 9. The model explained approximately 30% of the variance in continued participation intention.

Table 9: Research Model Results

	Base Model	Feedback Model		
		Main Effects	Volume * Motivations	Valance * Motivations
R^2	0.3023	0.3418	0.3620	0.3822
ΔR^2		0.0395	0.0202	0.0404
Project Attributes				
Project Ownership	.0000	0.0000	0.0000	0.0000
Project Users	-0.0001	-0.0000	-0.0000	-0.0000
Project Update	0.0000	0.0000	0.0000	0.0000
Project License	0.0000	0.0000	0.0000	0.0000
Project Innovativeness	0.0002**	0.0001**	0.0002**	0.0002**
Individual Attributes				
Gender (1=Female)	0.0000	0.00000	0.0000	0.0000
Age Group	-0.0000	-0.0000	0.0000	-0.0000
Education	-0.0000	-0.0000	0.0000	0.0000
IS Experience	0.0000	0.0000	0.0000	0.0000
OSD Experience	-0.0000	-0.0000	-0.000	-0.000
Tenure in Project	0.0000	0.0000	0.0000	0.0000
Contribution (1=Free)	-0.0000	-0.000	0.0000	0.0000
Motivations				
Extrinsic Motivation	0.0323**	0.0299*	0.0332*	0.0401*
Intrinsic Motivation	0.2892***	0.2565***	0.2309**	0.2524**
External Feedback Characteristics				
Volume		-0.0002**	-0002**	
Valence		0.0000		0.0000
Interaction Effects				
Volume * Extrinsic Motivation			0.0002*	
Valence * Extrinsic Motivation				0.0002*
Volume * Intrinsic Motivation			-0.0001	
Valence * Intrinsic Motivation				-0.0002*

Note: *p = .05; **p< 0.05; ***p < 0.01

In the second phase, we tested the feedback model's main effects in which we included volume and valence of external feedback in the OLS regression along with the base model

variables. The model explained approximately 34.18% of the variance in continued participation intention in OS projects. The variance explained by the feedback model main effects and the base model combined was significantly higher (3.95%) than the model that included only the base model variables. The results supported our hypothesis H1a but did not support H1b. The results in Table 9 show that volume of external feedback significantly impacts IS professional's continued participation intention. However, instead of positively impacting, as we hypothesized in the H1a, the results show that volume has a negative impact on continued participation intention. The results also showed that valence of external feedback positively impact continued participation intention, though the relationship was not statistically significant. Intrinsic and extrinsic motivations continued to significantly impact the dependent variables in the main effects model.

In the third phase, we tested the interaction effects between motivations characteristics of external feedback. As mentioned earlier, we split the model in which we first tested the interactions between volume and the motivations, then we tested the interactions valence and motivations. The first set of interactions added 2.02% additional variance explanation to the main effects. We found that volume significantly ($B = -.00017$, $p < .05$) significantly impact continued participation intention supporting H1a. We also found that the interaction effect of volume and extrinsic motivation significantly impacts continued participation intention supporting H2a. The second set of interactions added 4.04% additional variance explanation to the main effects. We found that the interaction effect of valence and extrinsic motivation and valence and intrinsic motivation significantly impacts continued participation intention supporting H2b and H3b.

Table 10: Robustness Test Results

	Base Model	Feedback Model	
		Main Effects	Interaction Effects
R^2	0.3023	0.3418	0.4220
ΔR^2		0.0395	0.0802
Project Attributes			
Project Ownership	.0000	0.0000	0.09
Project Users	-0.0001	-0.0000	-0.20
Project Update	0.0000	0.0000	0.20
Project License	0.0000	0.0000	0.10
Project Innovativeness	0.0002**	0.0001**	0.54**
Individual Attributes			
Gender (1=Female)	0.0000	0.00000	0.12
Age Group	-0.0000	-0.0000	-0.02
Education	-0.0000	-0.0000	0.00
IS Experience	0.0000	0.0000	0.02
OSD Experience	-0.0000	-0.0000	-0.03
Tenure in Project	0.0000	0.0000	0.08
Contribution (1=Free)	-0.0000	-0.000	0.02
Motivations			
Extrinsic Motivation	0.0323**	0.0299*	0.30**
Intrinsic Motivation	0.2892***	0.2565***	0.25*
External Feedback Characteristics			
Volume		-0.0002**	-0.49**
Valence		0.0000	0.34
Interaction Effects			
Volume * Extrinsic Motivation			0.29
Valence * Extrinsic Motivation			0.61**
Volume * Intrinsic Motivation			-0.19
Valence * Intrinsic Motivation			-0.44

Note: *p< 0.05; **p < 0.01

Robustness Analysis

To ensure the robustness of our analysis, we also conducted regression analysis using all interaction effects in one regression. The results are provided in Table 10. The model explained approximately 42% of the variance in continued participation intention in OS projects. The variance explained by the interaction effects was significantly higher (8.02%) than the model that included only the base model and the main effects. The results for volume and valence remained

fairly similar to what we found in the main effects though there were slight reduction in the coefficients. The results also showed that valence of external feedback and extrinsic motivation interacts positively to impact continued participation intention. The results support H1a and H2b in addition to showing that both intrinsic and extrinsic motivation have significant positive impact on continued participation intention.

DISCUSSION

Development of information systems in the open source environment is becoming more prevalent (August et al. 2018). The reasons for volunteers to join an OSD project is not necessarily the same as the reasons for them to continue to take part in the project. Since continuous improvement is part and parcel of software development, what influences volunteer's intention to continue to participate in an OSD project remains as a research interest to IS scholars (Ho and Rai 2017). The goal of this study was to examine how external feedback can impact continued participation intention of IS professionals.

Our study attempted to answer the research question by using primary data collected through cross-sectional surveys that included responses from 133 IS professionals working on open source software development projects. We started with a base model that included various OS project attributes and individual attributes. The project attributes included but not limited to ownership, intended users and innovativeness. The individual attributes included both demographic controls (e.g., age, gender), IS and OS related experience. The base model also included intrinsic and extrinsic motivations. The base model showed that both intrinsic and extrinsic motivation play significant roles in influencing an IS professional's intention to continue participating. The results also show that IS professionals tend to put a significant weight on the innovativeness of the OS project when it comes to continuing to participate in an OS

project. We also found that the intention to continue contributing in an OS project is negatively impacted when the intended users include people who are not the contributors (e.g., user who are not developers). The feedback model show that volume and valence significantly influence continued participation intention. Finally, our findings corroborated that volume and valence interact with intrinsic and extrinsic motivation to impact continued participation intention of IS professionals in OS projects.

Theoretical Implications

Our study makes enhances the open source literature in two ways. Our study enhances the open source literature by examining the impact of external feedback on the intention to continue participating in OS projects. Fang and Neufeld (2009) demonstrated that a large portion of OS projects fail because of discontinuation of volunteer participants. Years later Ho and Rai (2017) argued that continued participation is still an ongoing problem for open source software development. The existing literature have examined various reasons for participation of volunteers in OS projects that include, but not limited to, motivations (e.g., Roberts et al. 2006), project characteristics (e.g., Ho and Rai 2017), future rewards (e.g., Hars and Ou 2002), commitment to OS community (e.g., Maruping et al. 2019). Many researchers have also controlled for several attributes such as education, age, gender, and experience. However, the existing literature have not examined whether external feedback from users of OS projects has any impact on participation. We contribute to the open source literature by examining the effect of external feedback on participation, especially on the intention to continue contributing in the OS project they are working on.

We built on the existing literature in two ways. First, we developed a base model that included a range of project and individual or personal attributes using various control variables

that are found in the open source literature such as education, experience. We also included intrinsic and extrinsic motivations in the base model. Given that motivations are aspects of the an individual, we included the motivations in the individual attribute's category. Second, once the base model is tested, we included the importance of feedback in the mix of factors. Our results support the notion that feedback is indeed an important factor that can impact an IS professional's intention to continue participating given that characteristics of external feedbacks impact continued participation intention. Hence, our findings contribute to the OS literature by demonstrating that not only intrinsic and extrinsic motivation play important roles in the context of OS projects as shown by many OS researchers (e.g., Roberts et al. 2006), but also shows that external feedback can influence intention to participate in further development of the OS project.

Second, we contribute to the OS literature by providing a nuanced understanding of the impact of external feedback on continued participation intention in OS projects. We examined how two characteristics of external feedback – volume and valence, may impact the continued participation intention of IS professionals. We picked volume and valence as we felt that these two are easily understandable characteristics of external feedback. In addition, we examined the interaction between characteristics of external feedback and motivations. Our results showed that volume negatively impacts an IS professional's continued participation intention. The results also showed that valence positively impacts continued participation intention though the relationship was not found to be significant. Most importantly, we While volume and valence are perhaps not the only characteristics of external feedback that may have impact on participation intention, we believe our study findings provides a starting point for more nuanced examination of external feedback and how these feedbacks impact IS professional's intention to continue participating in ongoing OS projects.

Practical Implications

This study helps practitioner such as open source software project owners or managers and OS development platforms in two ways. First, the study reinforces that external feedbacks are important aspects of open source development and therefore should be accommodated. The OS platforms have been accommodating external feedbacks in the form of reviews of OS projects. This study ties external feedback to continued participation of IS professionals contributing in OS projects. This relationship makes the external feedbacks an important aspect not only to potential users but also to the contributors and therefore sheds a new a light on the usefulness of external feedbacks. Second, by examining the impact of volume and valence on continued participation of volunteers, this study encourages OS project owners to take more detailed initiative about external feedback. It is understandable that OS project owners or platforms cannot enforce strict rules about external feedbacks, which may discourage users from giving feedback. However, they can establish and market guidelines to users by highlighting the fact that the users' feedback are important, and they should keep the characteristics (e.g., volume, valence) of their feedbacks in mind when they provide such feedback. After all, it is only logical to assume that the users who provide feedbacks would want their feedbacks to be heard and heeded. Hence, if they are aware that giving a feedback in a certain way (e.g., writing a less voluminous review) would have more impact on the development of the OS project, they would be mindful when they provide such feedbacks.

Limitations and Suggestions for Future Research

Our study is not without limitations. Even though we collected data on several project attributes such as quality control, extent of communication, and cooperative norms. These were noted as important factors by Ho and Rai (2017) in their study of continued participation in OS

projects. However, due to validity issues, we were not able to include these three important variables in our final analysis. However, we believe our base model would have been more comprehensive if we had these three variables included in the model. Given that Ho and Rai (2017) had a not validity issues with their measures, we think future researchers should include these variables in their base model with a different sample.

Even though we found that valence positively influences continued participation intention, we did not find statistical significance for this sample. However, this finding does not diminish the necessity to include valence in future research. On the contrary, we think future researchers should include additional question about valence asking respondents to mention a reason if they do not think valence is an important factor. For our study, volume or valence were not communicated to the respondents, instead, these characteristics were implied in the sample feedbacks we showed to the respondents. Now that this research has shown that characteristics of external feedback can potentially impact continued participation, future researchers may take a more explicit method to communicate the characteristics of external feedback to understand their impacts better. We also think future researchers have the opportunity to cover more characteristics of external feedback. We have only covered volume and valence in our study, but it is possible that a feedback may have other attributes that may impact continued participation intention. For instance, understandability of the feedback could be a potential characteristic that future researchers can examine.

Interestingly, the results reveal that IS professionals intend to continue working on OS projects when the intended users are those who are contributing in the project. This is interesting because the existing literature shows that altruism positively (e.g., Hars and Ou 2002) impacts participation. However, the results appear to suggest that the intention to participate goes down

when the intended users include people other than those who are contributing. Does this mean that IS professionals are averse to providing services to those who are only consumers or something more complicated. Future researches can look into this issue deeper, perhaps by asking an open-ended question. Future researchers can also further look at the question of innovativeness. Open source software development is a form of open innovation, and therefore it is very logical that IS professionals will care about OS projects that are more innovative. However, our study only covered innovativeness as a binary option. Future researchers can develop scales that captures more in-depth understanding of the innovativeness of an OS project.

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Conclusion

Open source software development is an emerging topic of interest for researchers and practitioners alike. Even though it is not necessarily a very new phenomenon, research on open source development has been largely focused on participation in OS projects. However, as the domain has matured, it is time to apply and examine how managerial and psychological constructs, constructs that provided great understanding in the traditional work environment, can play a role in advancing our understanding in the open source environment. The three essays in this dissertation examine how engagement and participation of information systems professionals in open source projects and open source platforms are influenced. By exploring the role of various antecedents and outcomes of engagement and participation of information systems professionals in the open source projects and host platforms we hope to spark the conversation about the potentials of studying these constructs in the open source software development environment. We hope future researchers will build on the findings and further our understanding of this great phenomenon of open source software development.

Appendix A

University of Arkansas Internal Review Board Approval for Data Collection

UNIVERSITY OF ARKANSAS

To:	Pankaj Setia WCOB 224
From:	Douglas James Adams, Chair IRB Committee
Date:	06/28/2019
Action:	**Exemption Granted**
Action Date:	06/28/2019
Protocol #:	1906202053
Study Title:	Open Source Development Survey

The above-referenced protocol has been determined to be exempt.

If you wish to make any modifications in the approved protocol that may affect the level of risk to your participants, you must seek approval prior to implementing those changes. All modifications must provide sufficient detail to assess the impact of the change.

If you have any questions or need any assistance from the IRB, please contact the IRB Coordinator at 109 MLKG Building, 5-2208, or irb@uark.edu.

cc: Saifur Rahman Bhuiyan, Investigator

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