Effects of Empowerment on Performance in Open-Source Software Projects

Weiling Ke and Ping Zhang

***Abstract*—An enduring issue that intrigues researchers and practitioners in open-source software (OSS) development is what motivates individuals to participate and make contributions, given the lack of numerating mechanisms. Amidst several end-state-focused motives advocated by prior studies (such as improved programming skills and future career growth), we add that an important contributing factor is *empowerment*, the positive feelings derived from task assessments in OSS projects. Through survey data collected from 233 OSS participants, we assess how components of psychological empowerment (i.e., autonomy, competence, meaningfulness, and impact) derived from OSS tasks may affect the work output of participants. In particular, we demonstrate that competence and impact have a positive influence on OSS participants' performance, while autonomy and meaningfulness have a slightly negative influence on performance. In addition, empowerment's effects on performance can be mediated by effort expended. Theoretical contributions and managerial implications of this study are discussed.**

***Index Terms*—Empowerment, open-source software (OSS), software-development participation.**

I. Introduction

THE phenomenon of open-source-software (OSS) development has attracted increased and enduring attention from scholars and practitioners in recent years [e.g., [20], [38], [39], [68], and [69]]. In particular, a question that presents a challenge to researchers is why individuals make contributions although most projects do not have a remunerating system. Prior studies have primarily been anchored on the argument that the end states of participation are the motivation for individuals in OSS projects [e.g., [3], [43], [61], and [64]]. For instance, Hertel *et al*. [30] and Shah [64] examined how improved programming skills and developing software unavailable in the market motivate individuals to participate in OSS communities. Also, Roberts *et al*. [61] investigated how pragmatic motives such as seeking reputation and possible future financial rewards lead individuals to make contributions to OSS projects.

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W. Ke is with the School of Business, Clarkson University, Potsdam, NY 13699 USA (e-mail: wke@clarkson.edu).

P. Zhang is with the School of Information Studies, Syracuse University, Syracuse, NY 13244 USA (e-mail: pzhang@syr.edu).

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The majority of existing studies have limited implications to the adjacent context of proprietary software development. Specifically, prior research has predominantly revolved around the issue of participants' intrinsic and extrinsic motivations. An exception is Ke and Zhang [39], which investigate the effects of social factors (i.e., OSS ideology conviction and identification with the group), in addition to that of intrinsic and extrinsic motivations. Yet, all these factors are end-state-oriented motivations, and they are not unique to the OSS communities, but can similarly motivate individuals in proprietary software development projects [29]. For example, individuals in both contexts can be motivated by interests in reputation, seeking enjoyment, future career growth or strong identification with the project group. Thus, what is learned from OSS research about motives on the end states of participation offers little new lessons to the proprietary software development [29]. To address this shortfall in the extant literature, we investigate the effects of motivating factors embedded in the participation *process*. In particular, drawing upon empowerment theory [65], [71], we examine how empowerment affects individual performance in OSS projects.

Empowerment refers to positively valued feelings that an individual may derive directly from task assessments and refer to the task itself [65], [71]. A task refers to a set of activities directed toward a purpose [71]. According to empowerment theory, empowerment motivates individuals to be engaged in the task and achieve good performance [65], [71]. In an OSS project, individuals work together to complete the task of collective software development, which involves many specific activities, such as writing lines of codes for a program, debugging a program, or writing documents for a program. Also, they are directed toward a specific purpose, such as adding features to a particular software product. Therefore, tasks can be project specific. As described in detail in the below section, the characteristics of task design in OSS projects tend to allow participants to derive a sense of empowerment. Hence, examining how empowerment affects performance may shed new light on why individuals make contributions to OSS projects and afford managerial implications that can be extended to proprietary software development. The current paper intends to investigate the effects of empowerment's components on performance since prior research suggests their differential effects (e.g., [70]).

While previous studies on empowerment have focused on its components' direct effects on performance, we examine the mediating effects of task effort due to two reasons. First, it is well established that performance is a function of ability and effort, and effort may be affected by perceptions and psychological states [44], [58], and other factors such as

available time or energy. According to motivation theory, a motivational construct, such as empowerment, affects individual intention to act [18], [55], but may not lead to behavior outcomes directly [48]. Thus, empowerment would translate into accomplished work by means of the effort expended on the task [7], [41], [55]. Indeed, the mediating effects of task effort in the association of motivating factors and performance gains empirical support from Ke and Zhang [39]. Second, empirical findings on the direct effects of empowerment have been mixed and even controversial. For example, Thomas and Tymon [70] found no relationship between competence, one of the critical components of empowerment, and performance, while Locke and Shaw [49] found that competence is positively related to performance. The mixed findings indicate that an examination of possible mediating effects may extend our understanding of empowerment's effects on performance, resolving the inconsistencies in the extant literature. The current research context makes it even more important to investigate the possible mediating effects of effort since many other important tasks, such as jobs or study, compete against the OSS project task for the individual's time and effort [39]. The individual may derive psychological empowerment from the OSS task, but may not expend effort on it, due to limited time and energy. Thus, the possible mediating effect of effort warrants scrutiny.

The rest of the paper is organized as follows: We first present the theoretical background, followed by arguments supporting our research model and hypothesized relationships. Next, we describe the research methodology and present data analysis results. Finally, the paper ends with discussions and implications for theory and practice.

II. Theoretical Underpinnings and Research Hypotheses

A. Empowerment and Effort

The concept of empowerment has been developed and advanced in recent decades (e.g., [10], [14], [65], and [71]). Previous research demonstrates that empowerment would unleash individuals' potential, energize individuals, and improve their performance [36], [65]. There exist two conceptions of empowerment in the extant literature. One approach defines it as "a practice, or set of practices involving the delegation of responsibility down the hierarchy so as to give employees increased decision-making authority in respect to the execution of their primary work tasks" [45, p. [28]. The other approach, which is the focus of the current study, considers empowerment as the positively valued feelings that an individual may derive directly from his or her cognitions about him- or herself in relation to the task [24], [63], [65], [71]. In particular, this approach conceptualizes empowerment as a gestalt of four types of feelings, namely, autonomy (or self-determination), competence, meaningfulness (or meaning), and impact [65], [66], [71]. Autonomy refers to a sense of freedom in making choices about how to perform the task, and being personally responsible for the results. For example, participants in an OSS project can decide how they would like to contribute to the project. Competence is defined as the belief in one's ability to perform the task successfully. For instance, individuals in an OSS community feel confident about the small portion of the project they choose to work on. Meaningfulness is the perceived value of the task in relation to one's personal beliefs, specifically attitudes and values. For example, participants in an OSS project may identify with the free source movement and regard their performing OSS-related tasks as meaningful. Impact refers to the belief that one is producing intended effects and has control over desired outcomes [65], [71]. For example, individuals in an OSS project have the right to decide the features to be included in the official release of the software.

The notion of empowerment is grounded on the thesis that an individual's assessment of a task exerts influence on the individual's feelings toward performing the task, and thus affects the behavior outcomes [24], [27], [65]. This is consistent with what is suggested by job design theory [27]. Prior studies on empowerment have examined its direct effects on behavior outcomes in traditional organizational contexts (e.g., [63] and [65]). For instance, Spreitzer *et al*. [67] examine the contribution of empowerment on work effectiveness, work satisfaction, and job-related strain. Also, Renn and Vandenberg [60] investigate the effects of meaningfulness on work performance. However, the research findings of prior studies are mixed and even controversial. For example, Thomas and Tymon [70] found no relationship between competence and performance, while Locke *et al*. [49] found that competence is positively related to performance. An exploration of possible mediators in the relationship between empowerment and performance may help resolve such inconsistencies.

According to motivation theory, a motivational construct, such as empowerment, may be translated into performance by means of effort expended on the task [55]. Specifically, Parsons [55] defined effort as the means by which motivation translates into accomplished work. This definition suggests that effort plays a mediating role between motivation and behavior outcomes. Empowerment, as positively valued feelings, motivates an individual to initiate actions. But it may not be able to lead to behavior outcomes directly. Instead, it is the effort through which empowerment, as a motivating variable, is translated into behavior outcomes [7], [41]. Alternatively, if there is no effort, empowerment, like other motivating constructs, may not affect behavioral outcomes [48], [50]. The mediating effect of effort in the relationship between motivation and performance has gained empirical support in psychology and marketing disciplines [7], [8], [13]. In addition, in the OSS context, Ke and Zhang [39] found that motivating factors affect performance through effort.

The notion that an individual's empowerment affects his or her performance can be extended to the OSS context for three reasons. First, tasks in OSS projects, similar to job tasks in traditional organizations, are the basic components of projects. These tasks must be completed by participants to create value for the project's stakeholders [3]. Second, it is through working on tasks that an individual makes contribution to the OSS community, i.e., individuals interact with the community through tasks such as fixing bugs and requesting features. As such, empowerment derived from task assessments play a more immediate role in

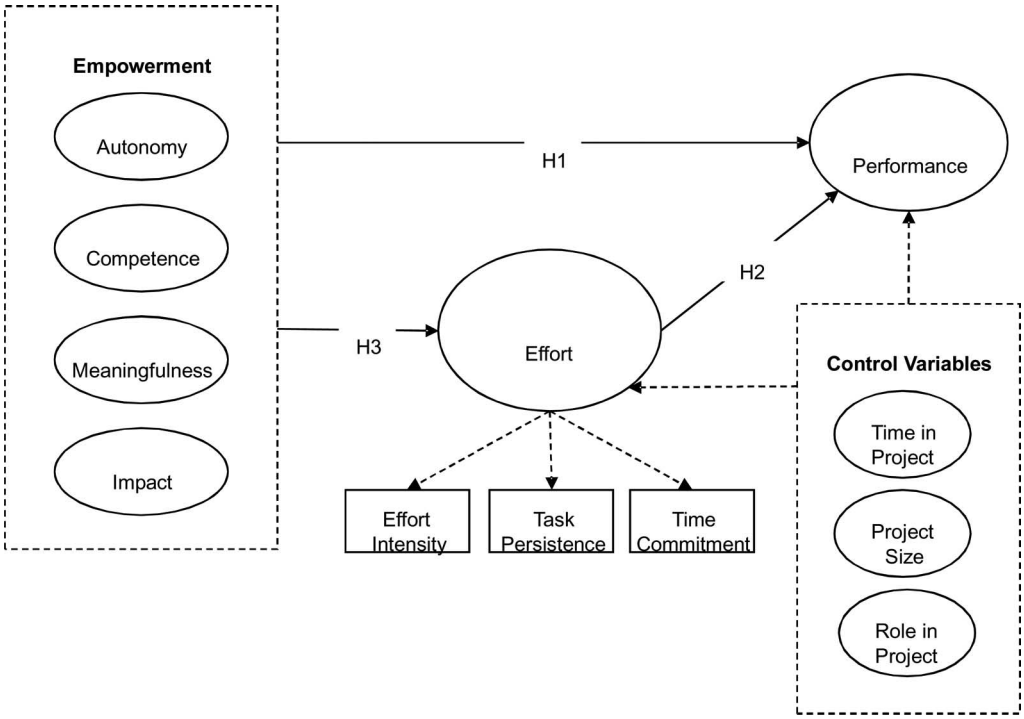

Fig. 1. Research model.

influencing individual engagement and performance than facilitating conditions in the environment [29], [46]. Third, tasks in the OSS community allow psychological empowerment to emerge due to their special characteristics such as self-direction and timely feedback [30], [46]. Indeed, such task characteristics are regarded as empowering factors by studies on enriched job design [27], [65].

B. Hypothesis Development

Fig. 1 depicts our research model. We propose that empowerment induced from the tasks in an OSS project provides opportunities for cultivating individual mind-set and energizing behavior [54], [67], [70]. To this end, we conceive that empowerment has a positive effect on behavior outcomes (i.e., performance). Performance refers to the cognitive outcome of individuals' conducting the task [72]. In the current study, we focus on the participants' perceived performance. It refers to the degree to which an individual perceives to accomplish OSS tasks better than others in the project group in the average. The thesis for the proposed conjecture is that, compared with the development of proprietary software, as mentioned above, tasks in an OSS project may have the following four characteristics which make psychological empowerment emerge in OSS communities.

First, tasks are *self-assigned* by participants rather than through the chain of commands [3], i.e., participants have a high degree of control over what tasks to take on and how to perform these tasks by following their own schemata, as opposed to following the orders from superiors [46]. From a cognitive perspective, individuals generally have more complete knowledge and information about what they can contribute, and therefore are in a better position than others to identify the right tasks to work on [15]. In addition, when an individual gains feelings of autonomy around task identification, assignment, and conduct, he or she may affectively experience the satisfaction of psychological needs, formulates a favorable attitude toward the task, and thus achieves high performance [17], [47], [70]. Provided that there is consistent support for the positive effects of autonomy on performance in prior research (e.g., [47] and [53]), we propose the following hypothesis.

> *Hypothesis 1a*: An individual's feeling of task autonomy is positively related to perceived performance in an OSS project.

Second, participants receive *timely and constructive feedback* on their work due to the widely distributed nature of the OSS community [29], [61]. Typically, an OSS project involves people living in different time zones, allowing participants to receive quick responses from others around the clock. Also, tasks in OSS projects tend to be modular and do not impose an overwhelming challenge on individuals. Thus, participants may gain feelings of competence as they initiate behaviors, seek continuous improvement, and search out innovative solutions to problems [16], [33]. Given that the positive relationship between competence and performance has gained empirical support from prior studies conducted in traditional organizational contexts (e.g., [4], [47], [48], and [67]) and in OSS communities [30], we have formulated the following hypothesis.

> *Hypothesis 1b*: An individual's feeling of competence is positively related to perceived performance in an OSS project.

Third, the products and source code of OSS projects are typically publicly available for free without any licensing fees [59], [74]. This emphasis on prosocial values, coupled with the goal

of helping other users, makes participants regard tasks in OSS communities as meaningful and significant [75]. They may even consider contributing to OSS communities intrinsically important. It is well established that an individual who feels meaningful would perceive that related tasks fulfill his or her desired values, and would therefore formulate a favorable attitude toward such tasks and achieve high performance [27]. Accordingly, we contend that the meaningfulness derived from assessing tasks in an OSS project positively affects individuals' performance, leading us to formulate the following.

Hypothesis 1c: An individual's feeling of task meaningfulness is positively related to perceived performance in an OSS project.

Fourth, decision making in OSS projects tends to be based on mutual agreements, relying on interaction among participants. For example, participants jointly determine whether individual inputs can be transformed into valuable collective outputs (i.e., what to be included in the official lease of the software), which, in turn, decides whether the project will sustain or decay [42], i.e., the dynamics and self-organization of participants determine how the project will progress. As such, participants may feel strongly that they are making an impact on the project [46]. When experiencing impact, an individual would tend to process information systematically, obtain an understanding of a situation, be aware of unexpected consequences of previous actions, and have information necessary to make accurate adjustments in performing the task [19], [32], [40]. Indeed, it is established that impact has a positive effect on performance [2], [67]. Accordingly, we propose the following hypothesis.

Hypothesis 1d: An individual's feeling of task impact is positively related to perceived performance in an OSS project.

Turning to effort, we propose its relationships with participants' perceived performance and the components of empowerment. Conceptually, effort consists of three components: commitment (or duration), intensity (or force), and direction [35]. Commitment is defined as the determination toward meeting a goal and the persistence in pursuing it over time [31]. It has two aspects, namely, time commitment and task persistence. Time commitment refers to the duration of time that the individual dedicates to the task, while task persistence is the individual's continued effort in overcoming difficulties when performing the task [72], [76]. Effort intensity is defined as the amount of resources that are expended, in other words, how hard a person tries to carry out a chosen behavior [35], [76]. In contrast, task direction is a person's behavioral choice, often measured as choice decisions between mutually exclusive courses of action [35].

The current study focuses on the first two dimensions of effort (i.e., commitment and intensity) for three reasons. First, individuals may participate in multiple OSS projects, and the current study is interested in those projects they dedicate most of their effort to (i.e., their effort direction is to work most actively on an OSS project for each individual). Second, it is established that commitment and effort intensity constitute the essence of working hard [7]. Third, time commitment, persistence, and effort intensity are of particular relevance for the current research context. As mentioned above, most OSS participants are volunteers and there are other important tasks requiring their effort, such as jobs and study. These other tasks may compete against OSS tasks for participants' time, which affects their time commitment and effort intensity in OSS projects. In addition, as OSS participation may not be an individual's top priority. When other tasks become demanding, the individual may decide not to expend time and effort to the OSS project. As such, the individual may not be able to work persistently on the project. Therefore, it is appropriate for the current study to focus on these three components of effort. In the view that there is consistent support for the positive effects of effort on performance (e.g., [72] and [76]), we expect that effort expended by a participant is positively related to the individual's performance in an OSS project.

Hypothesis 2: An individual's effort expended on a project is positively related to perceived performance.

In OSS projects, empowerment induced from tasks may drive an individual to expend efforts. According to psychology theory, an individual has social psychological needs for autonomy and competence [18]. Satisfying these needs will enhance the individual's well-being and put him or her in a positive affective state [18]. Thus, these needs motivate the individual to take on and be engaged by tasks that may provide them with a sense of autonomy and competence [62]. Following this position, we expect that feelings of autonomy and competence in an OSS project may energize an individual to expend high levels of effort on the tasks in the project. In other words, in addition to their direct effects, autonomy and competence may affect performance through their influence on effort in OSS projects. This leads us to the following two parts of a four-part hypothesis.

Hypothesis 3a: An individual's feeling of task autonomy in an OSS project is positively related to effort expended on this project.

Hypothesis 3b: An individual's feeling of competence in an OSS project is positively related to effort expended on this project.

Similarly, effort may mediate the association between meaningfulness and performance. With the feelings of meaningfulness, an individual perceives the value of a task to be aligned with his or her personal beliefs, values, and norms. He or she would endorse the task with legitimacy and significance and come to intrinsically care about the task [34]. Expending effort on such tasks is regarded as purposeful, worthwhile, and rewarding [18]. Therefore, the sense of meaningfulness derived from tasks would play a motivating role and energize an individual's effort toward these tasks [37]. Extending this logic to the OSS context, we expect that meaningfulness may positively affect effort expended by an individual, and thereby influence the behavior outcomes. This leads us to the third part of hypothesis 3.

Hypothesis 3c: An individual's feeling of task meaningfulness in an OSS project is positively related to effort expended on this project.

In addition, impact is believed to result in effort [37], [71]. Specifically, when an individual has the opportunity to impact the decision making in the system, he or she would feel satisfied with the outcome and gain a sense of ownership, which leads to the individual's commitment, involvement, and concentration of energy expended on the series of related activities [71]. Therefore, the feelings of impact would motivate and energize

TABLE I
SAMPLE DEMOGRAPHY AND THEIR PARTICIPATION IN THE OSS PROJECTS

Category		Frequency (n=233)	Percent
Gender	Female	10	4.3%
	Male	216	92.7%
Age	18-21 years old	17	7.3%
	22-25 years old	36	15.5%
	26-30 years old	57	24.5%
	31-35 years old	34	14.6%
	36-40 years old	27	11.6%
	40-50 years old	39	16.7%
	51 and above	21	9.0%
Education	High school or below	17	7.3%
	Two years college	25	10.7%
	Bachelor Degree	99	42.5%
	Master Degree and above	90	38.6%
	Others	2	0.9%
Role Played in the OSS Project	User of the product of this project (use the code as it is)	26	11.2%
	User of applications that built on the product	114	48.9%
	Core developer of this project	62	26.6%
	Peripheral developers (bug reporting and fixing)	9	3.9%
	Translator	8	3.4%
	User Experience/User Interface Expert	7	3.0%
	Other	7	3.0%
Project Size (number of people in the immediate group)	0-10 people	98	42.1%
	11-30 people	39	16.7%
	31-99 people	22	9.4%
	100 + people	38	16.3%
Years of involvement in the project		Mean=3.75	Std=3.27

an individual to expend effort on the tasks in an OSS project. As such, we propose the fourth part of hypothesis 3.

> *Hypothesis 3d:* An individual's feeling of task impact in an OSS project is positively related to effort expended on this project.

To account for the differences among individual participants, we consider three control variables pertinent to the characteristics of the OSS projects. These variables include project team size, length of a participant's involvement in the OSS project, and the primary role a participant plays in the OSS project. We select these variables because they may have an impact on effort expended on the project, although investigation of these variables' effects is scant in the extant literature. For example, project team size, to a certain extent, manifests its success and thus may inspire participants to expend more effort. Also, the role played by an individual in the project may affect the level of effort expended. In particular, a core developer may be more affectively involved in the project and thus expend more effort than a peripheral developer.[1]

III. RESEARCH METHODOLOGY

A. Data Collection

Our data were collected as part of a larger effort using a survey distributed to OSS project participants. In addition to randomly selecting potential respondents from the discussion forums hosted by sourceforge.net, we also randomly chose respondents participating in some other online forums such as MySQL and OpenOffice. The rationale for doing so is to have a more representative sample and to avoid excluding participants

[1]Core members consist largely of developers who contribute most of the foundational programming code of OSS projects, while peripheral member are typically active users whose contributions may only address minor bugs or patches.

in some most significant projects from the current study. We sent out about 2000 invitations, asking participants to fill out a questionnaire posted on SurveyMonkey.com, an online survey service provider. We sent reminders in each of the following two weeks encouraging them to complete our survey. A total of 250 people responded to our invitations, resulting in a response rate of 12.5%. We disregarded 17 of the returned questionnaires as they were incomplete. In total, 233 surveys were analyzed to test our model. The entire survey took about 15 min to complete (though we should note again that elements of it were designed to also capture data regarding a larger project). Participants were asked to first describe the particular OSS project that they were recently most actively involved with, and then to answer the questionnaire based on that project. The demographic data of the respondents are shown in Table I. We would like to note that the large standard deviation of Years of Involvement in the Project was because the data were spread out over a large range of values (i.e., ranging from 12 days to 17 years).

We tested the nonresponse bias with the method suggested by Armstrong and Overton [1], comparing the Chi-squares of the responses from the first 25% of the respondents with that of the final 25%. A significant difference would indicate the presence of nonresponse bias. The result of our test showed that there was no nonresponse bias.

TABLE II
DESCRIPTIVE STATISTICS OF ALL VARIABLES

Constructs	Item	Mean	Std
Empowerment: Autonomy	EM_AUTO1	4.33	0.90
	EM_AUTO2	4.38	0.87
	EM_AUTO3	4.48	0.84
Empowerment: Competence	EM_AUTO2	4.38	0.87
	EM_AUTO3	4.48	0.84
	EM_CMP3	4.01	0.97
Empowerment: Meaningfulness	EM_MEAN1	4.04	0.86
	EM_MEAN2	4.11	0.81
	EM_MEAN3	4.20	0.74
Empowerment: Impact	EM_IMP1	3.63	1.26
	EM_IMP2	3.10	1.44
	EM_IMP3	3.52	1.34
Effort: Time Commitment	TIME_CM1	3.26	1.28
	TIME_CM2	3.68	1.31
	TIME_CM3	2.72	1.33
Effort: Task Persistence	TASK_PST1	3.69	1.05
	TASK_PST2	3.77	1.01
	TASK_PST3	4.12	0.86
Effort: Effort Intensity	EFF_1	4.05	0.90
	EFF_2	3.73	1.09
	EFF_3	4.29	0.83
	EFF_4	3.98	0.99
Performance	TASK_PRF1	2.89	1.29
	TASK_PRF2	3.05	1.13
	TASK_PRF3	2.83	1.14

B. Measures

The measurement items in our questionnaire were adapted from existing validated and well-tested scales in the extant literature. All questionnaire items were measured with five-point Likert scales, ranging from "strongly disagree" to "strongly agree" as well as the choice of "not applicable." Appendix I shows all measurement items. Components of empowerment were measured using a 12-item scale developed by Spreitzer [65]. The scale was adapted to the OSS project context with items referring to an individual's feelings derived from the assessments of tasks in a specific project. Also, we adapted the measurement items for effort from Yeo and Neal [76] and Tsai *et al*. [72]. Specifically, we used a shortened version of the effort scale, with three items for each dimension of effort. In addition, we adapted the scale for performance from Tsai *et al*. [72]. Minor modifications were made to the original scale to fit the current research context. Table II shows the descriptive statistics of all variables.

C. Common-Method Bias

While collecting perceptual data provides us with more accurate information about respondents' feelings and efforts expended, the data were collected from a single source at one point in the time. As such, common method bias was a concern, such as the threat of social desirability [56]. Before the research model and the hypotheses were tested, we assessed the possibility of common method bias with the Harman's one-factor test [57], i.e., we entered all items into a principal components analysis with varimax rotation [9]. According to this technique, common method bias may exist when a general construct accounts for the majority of the covariance in the measure scores. In our analysis, the results indicated that there were five constructs with eigenvalues greater than 1.0. These five constructs accounted for 69.29% of the variance while the first construct only accounted for 20.78% of the variance. To further ensure common method bias was not a serious threat, we also compared the fit between the one-factor model and measurement model. The results showed that the one-factor model yielded a $\chi^2 = 3261.2$ and d.f. $= 405$, and the measurement model yielded a $\chi^2 = 893.6$ and d.f. $= 369$. Thus, the fit of the one-factor model was considerably worse ($p < 0.01$) than the fit of the measurement model. This indicated that common method bias is not a serious concern.

IV. DATA ANALYSIS AND RESULTS

Partial least squares (PLS, PLS-Graph 3.00) was utilized to assess the measurement scales and the proposed hypotheses due to its advantages of minimal demands on measurement scales, sample size, and residual distributions [12], [21]. PLS is a component-based structural equation modeling technique that is suited for exploratory research models where there are new relationships to be tested. There were two stages for data analysis. In Stage 1, all items in the instrument were assessed in a measurement model for reliability and construct validity using confirmatory factor analysis (CFA). In Stage 2, the proposed model and hypotheses were tested, where individual path coefficients and variance explained in the dependent variables were examined. In both stages, all measured items were modeled as reflective indicators of their corresponding latent constructs.

TABLE III
CORRELATION BETWEEN MEASURES AND LATENT VARIABLES*

	EM_MEAN	EM_CMP	EM_AUTO	EM_IMP	TIME_CM	TASK_PST	INTENSIT	TASK_PRF
EM_MEAN1	0.82	0.34	0.25	0.50	0.50	0.39	0.43	0.29
EM_MEAN2	0.90	0.26	0.26	0.29	0.35	0.35	0.32	0.19
EM_MEAN3	0.89	0.29	0.21	0.37	0.33	0.32	0.28	0.25
EM_CMP1	0.34	0.88	0.42	0.46	0.31	0.35	0.32	0.38
EM_CMP2	0.28	0.90	0.37	0.40	0.34	0.34	0.37	0.39
EM_CMP3	0.26	0.84	0.31	0.51	0.40	0.35	0.33	0.52
EM_AUTO1	0.24	0.46	0.86	0.37	0.16	0.17	0.16	0.20
EM_AUTO2	0.25	0.42	0.93	0.38	0.10	0.15	0.12	0.18
EM_AUTO3	0.22	0.23	0.85	0.26	-0.03	0.12	0.10	0.03
EM_IMP1	0.39	0.54	0.36	0.90	0.54	0.55	0.43	0.59
EM_IMP2	0.38	0.46	0.33	0.93	0.52	0.50	0.42	0.59
EM_IMP3	0.45	0.45	0.36	0.93	0.51	0.46	0.35	0.54
TIME_CM1	0.43	0.33	0.02	0.44	0.88	0.51	0.53	0.44
TIME_CM2	0.41	0.34	0.10	0.45	0.92	0.54	0.50	0.50
TIME_CM3	0.29	0.37	0.12	0.59	0.76	0.51	0.45	0.68
TASK_PST1	0.32	0.36	0.20	0.50	0.59	0.88	0.59	0.44
TASK_PST2	0.34	0.35	0.11	0.47	0.52	0.90	0.59	0.38
TASK_PST3	0.38	0.32	0.13	0.44	0.45	0.81	0.68	0.41
EFF_1	0.34	0.32	0.12	0.32	0.49	0.61	0.87	0.34
EFF_2	0.22	0.30	0.04	0.38	0.45	0.49	0.79	0.40
EFF_3	0.33	0.34	0.19	0.34	0.45	0.53	0.79	0.34
EFF_4	0.31	0.25	0.17	0.27	0.41	0.54	0.87	0.30
TASK_PRF1	0.30	0.47	0.16	0.66	0.67	0.50	0.44	0.91
TASK_PRF2	0.20	0.45	0.14	0.52	0.50	0.41	0.39	0.94
TASK_PRF3	0.28	0.45	0.13	0.56	0.57	0.42	0.42	0.94

*Note: All loadings are significant at $p < .05$.

A. Measurement Model

The measurement model was estimated by using a method of repeated indicators known as the hierarchical component model [51], because effort is a second-order construct on three dimensions. Convergent validity and discriminant validity were used to examine the measurement scales [28]. Convergent validity was assessed by reliability of items, composite reliability (CR) of constructs, and average variance extracted (AVE) [22], [76]. Reliability of items was assessed by each item's loading on its corresponding construct. A common rule of thumb suggests that the item loading should exceed 0.70 [5], [11]. Table III provides the confirmatory factor analysis loadings of the measurement items of all reflective variables. As shown in this table, the loadings for all items exceeded 0.70.

Table IV shows the CR of each reflective construct. It is recommended that CR should be 0.70 or higher, which is satisfied by all constructs. AVE measures the amount of variance that a construct captures from its indicators relative to the amount due to measurement error [11]. It is recommended that it should exceed 0.50 [5]. Table IV shows the AVEs of all constructs exceeded 0.50. Hence, all three conditions for convergent validity were met.

Discriminant validity between constructs was assessed using Fornell and Larcker's [22] recommendation that the square root of the AVE for each construct should exceed the correlations between this construct and all the other constructs [11], [22]. In Table IV, the shaded numbers on the diagonals are the square root of the AVEs. Off-diagonal elements are the correlations between constructs. All diagonal numbers are much greater than the corresponding off-diagonal ones, indicating satisfactory discriminant validity of all the constructs. Meanwhile, given that there were some high correlations between constructs in Table IV, we also conducted a Chi-square test to assess discriminant validity. Through comparing the Chi-squares of the constrained model and unconstrained model, we found that there were significant differences between these two models, further confirming the discriminant validity of our measurement model.

TABLE IV
INTERNAL CONSISTENCY AND DISCRIMINANT VALIDITY OF CONSTRUCTS

	Constructs	CR	AVE	1	2	3	4	5	6	7	8
1	EM_MEAN	0.91	0.76	0.87							
2	EM_CMP	0.91	0.76	0.34	0.87						
3	EM_AUTO	0.91	0.77	0.27	0.42	0.88					
4	EM_IMP	0.94	0.85	0.44	0.52	0.38	0.92				
5	TIME_CM	0.89	0.74	0.45	0.40	0.09	0.57	0.86			
6	TASK_PST	0.90	0.75	0.40	0.40	0.17	0.55	0.61	0.87		
7	INTENSITY	0.91	0.66	0.39	0.39	0.15	0.43	0.54	0.66	0.83	
8	TASK_PRF	0.95	0.87	0.28	0.49	0.16	0.62	0.62	0.48	0.41	0.93

Another criterion for discriminant validity is that no measurement item should load more highly on any construct other than the construct it intends to measure [11]. Based on this guideline [25], the difference between the loading on the supposed construct and the loading on other constructs should be more than 0.10. An examination of loadings and cross-factor loadings (see Table III) showed that all items satisfied this guideline.

In addition, as shown in Table IV, four inter-construct correlations were over the value of 0.60. This indicated that multicollinearity might be a potential problem for this research [26]. To detect multicollinearity, we assessed the variance inflation factors (VIFs) and tolerance values of the constructs. Generally, the common rule of thumb for the presence of multicollinearity is that VIFs are higher than 10 or tolerance values are less than 0.1 [52]. In this analysis, the results showed that the highest VIF was 2.49, and that the lowest tolerance value was 0.40. This indicated that multicollinearity was not a serious issue.

V. STRUCTURAL MODEL AND HYPOTHESES TESTING

To test the research model in Fig. 1, effort is treated as a reflective construct with the measures of the three first-order constructs. Table V and Fig. 2 summarize the results of the structural model that was analyzed with PLS-group 3.00. The R^2 for effort and performance are 0.47 and 0.53, respectively. Among the three control variables, only project size had a significant positive effect on performance. The research model was largely supported, with some exceptions on certain hypotheses. Specifically, competence and impact both had a positive significant effect on performance, with $\beta = 0.20$ ($p < 0.01$) and $\beta = .41$ ($p < 0.01$), respectively. Thus, Hypotheses 1b and 1d were supported. Yet, Hypotheses 1a and 1c were not supported since the empirical data showed that autonomy ($\beta = -0.10, p < 0.10$) and meaningfulness ($\beta = -0.11, p < 0.05$) had negative, rather than positive, effects on performance. The results also showed that effort had a significant and positive effect on performance ($\beta = 0.32, p < 0.01$), supporting Hypothesis 2. Autonomy had a significant, albeit negative, effect on effort ($\beta = 0.17$, $p < 0.01$). Thus, Hypothesis 3a was not supported. However, competence, meaningfulness, and impact had a positive effect on effort, with $\beta = 0.20$ ($p < 0.01$), $\beta = 0.26$ ($p < 0.01$), and $\beta = 0.42$ ($p < 0.01$), respectively. As such, Hypotheses 3b–3d were supported.

TABLE V
SUMMARY OF THE RESULTS

Constructs	Effort	Performance
Project Size	0.07	0.12*
Time in Project	0.03	0.04
Role in Project	0.02	-0.06
Autonomy	-0.17***	-0.10*
Competence	0.20***	0.20***
Meaningfulness	0.26***	-0.11**
Impact	0.42***	0.41***
Effort		0.32***
R2	0.47	0.53

Given that the extant literature has primarily focused on the direct effects of empowerment of performance, we conduct further data analysis to test the mediating effects of effort on the associations between empowerment components and performance. Such a test is important as its results would support the necessity of including effort in a research model on the relationship between motivating factors and behavior outcomes. We followed the three-step procedure suggested by Baron and Kenny [6]. As shown in Table VI, when effort was not in the model (step 1), all the four empowerment components had significant effects on performance (i.e., with a coefficient of 0.16, 0.47, 0.26, and 0.61 for autonomy, competence, meaningfulness, and impact, respectively). When effort was introduced as a mediator (step 3 in Table VI), the links between competence and performance (i.e., with a coefficient of 0.27), and between impact and performance (i.e., with a coefficient of 0.42) remained significant. Yet, the links between autonomy and performance (i.e., with a coefficient of 0.07), and between meaningfulness and performance (i.e., with a coefficient of -0.016) became insignificant. It indicated that effort fully mediated the relationships between autonomy and performance, and between meaningfulness and performance. In contrast, effort partially mediated the associations between competence and performance, and between impact and performance.

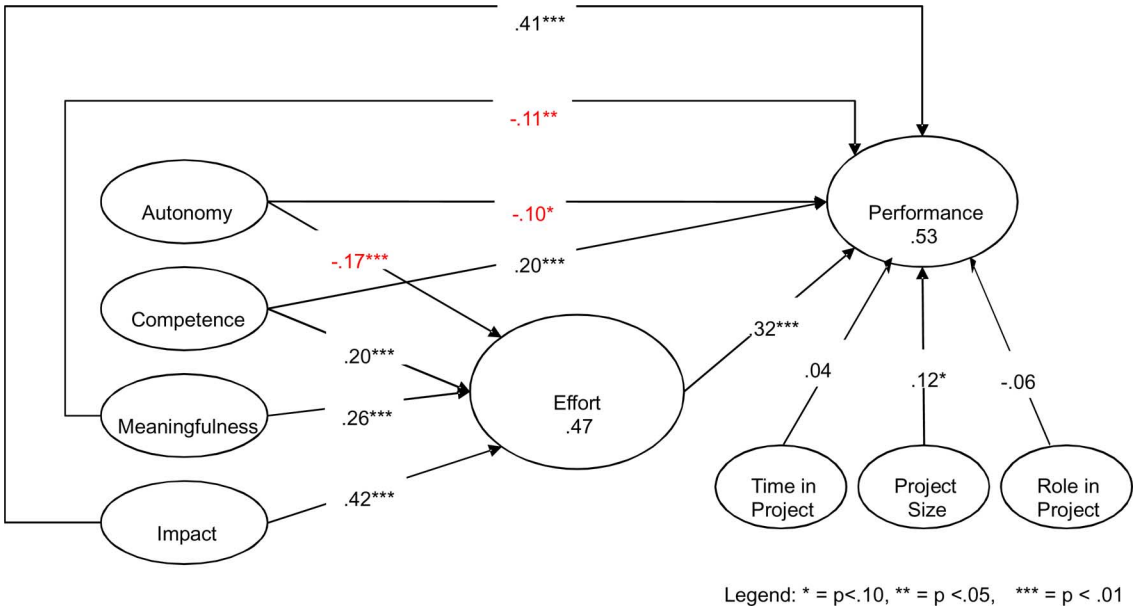

Fig. 2. Empirical model.

TABLE VI
RESULTS OF MEDIATING EFFECTS TEST

IV	M	DV	IV→DV	IV→M	IV&M→DV (Step 3)		
			Step 1	Step 2	IV-DV	M-DV	Mediating
AUTO	TASK_EFF	TASK_PRF	0.161**	0.143**	0.074	0.565***	Full
CMP	TASK_EFF	TASK_PRF	0.466***	0.419***	0.269***	0.461***	Partial
MEAN	TASK_EFF	TASK_PRF	0.255***	0.459***	-0.016	0.584***	Full
IMP	TASK_EFF	TASK_PRF	0.614***	0.580***	0.420***	0.335***	Partial

Note 1: p levels are indicated as follow: *p<0.1; **p<0.05; ***p<0.01.

Note 2: IV: independent variable; M: mediator; DV: dependent variable.

Step 1: Test whether the link between IV and DV is significant.

Step 2: Test whether the link between IV and M is significant.

If the links in Step 1 and 2 are significant, then move to Step 3.

Step 3: Test whether the direct link between IV and DV remains significant, with M being in the model. In this step,

(a) if the effect of M is significant and that of IV is not significant, then M has full mediating effect.

(b) if the effects of both M and IV on DV are significant, then M has partial mediating effects.

VI. DISCUSSION AND CONCLUSION

Our data analysis results show that competence and impact both have positive effects on performance, while autonomy and meaningfulness have negative effects. An explanation for the negative relationship between autonomy and performance would be that, while individuals may appreciate task autonomy, they may perceive that they have things under control and thus feel that there is no need to put too much effort on the task. Therefore, their performance is not as high as that of others. The negative effect of meaningfulness on performance may suggest that individuals with feelings of task meaningfulness are so enthusiastic about OSS that they may simultaneously participate in multiple projects, which makes their contribution to each project not as significant as others. Another possible explanation is that, when an individual perceives a high level of task meaningfulness, the task may lose the "mystery" or appeal of being challenging. Thus the individual may feel her or his performance is low, in comparison with that of others.

In addition, the present study reveals that, in addition to direct effects, components of empowerment indirectly influence performance through effort. The finding of mediating effects of effort in the relationship between developers' feelings and performance is in accord with the finding of previous studies conducted in proprietary software projects (e.g., [58]). Specifically, the effects of autonomy and meaningfulness on performance are fully mediated by effort. In contrast, competence and impact's effects on performance are partially mediated by effort.

To further investigate the notion that empowerment has an overall positive effect on performance, we conduct post hoc data analysis by introducing "empowerment" as a second-order construct. The results, shown in Appendix II, indicate that

empowerment indeed has both a positive direct and a positive indirect effect on performance.

A. Limitations

It is important to evaluate the current study's limitations before we highlight its contributions. One limitation is that there are other salient factors that can affect an individual's performance in an OSS project, such as leadership styles and the atmosphere of the OSS working environment. The focus of the current study is on empowerment; examining the effects of other factors is beyond the scope of the current study. Future research should formulate a more integrated model so that we can compare and contrast different drivers' effects.

The second limitation is that we collected all of our data during one period of time. All constructs were measured by respondents' perceptions, which are subjective. In particular, the measurement of performance is subjective rather than objective. A better alternative approach would be to seek the project administrator to provide the rating of the respondents' performance. We appeal that future research should try to use objective measures and across multiple time points. A longitudinal study may enrich research findings by offering additional information on the causal relationships between independent and dependent variables.

The third limitation is that we did not include task activity as a control variable in the research model. Activities in an OSS project can be reactive or deliberate. For instance, some activities may be assigned to the individual by the project leader (i.e., reactive) and the participant may initiate a request for adding in a new feature (i.e., deliberate). Also, the complexity of task activities may affect the individual's performance. As such, task activity would be an important control variable. Although the current study uses "role in the project" as proxy for task and makes it a control variable, it does not reflect the complexity of task or the nature of the task. Therefore, we appeal that future research measures and investigates the effects of task activity as a control variable.

The final limitation is that, since it is one of the first to examine the effects of empowerment on individuals' participation outcomes in OSS communities, we collected data from only English-speaking OSS participants. OSS development, as a global phenomenon, involves individuals speaking various languages in diverse cultures. Future research should be conducted to verify the applicability of our research results to participants in different cultures and speaking different languages.

B. Theoretical Contributions

Our study makes three major theoretical contributions. First, to the best of our knowledge, this is the first study investigating the effects of empowerment derived from the assessment of tasks in OSS projects. Different from previous studies that examine the effects of extrinsic, intrinsic, and/or other motivations (e.g., [23], [30], [38], [39], and [64]), the present research focuses on the effect of a process-oriented motivation, especially how task assessments arouse the feelings of autonomy, competence, meaningfulness and impact and thereby motivate individuals, i.e., the motives studied by prior research are primarily on the end states of participation. In contrast, the energizing source investigated in this research is embedded in the process of participating. Compared with previous studies including the work by Ke and Zhang [39], the present research focuses on the effects of feelings derived from the assessment of task in OSS projects. Such a focus allows us to advance our knowledge of OSS projects, contribute to the project management literature and extend our understanding of task design, which can be applied to the proprietary software development context.

Second, this research investigates how components of empowerment affect behavior outcomes. Most of previous studies have investigated how motivations lead individuals to participate in OSS projects and ignored the outcomes of such participation (e.g., [23], [30], and [64]). However, the act of participation is not equal to performing well. Given that the latter is more of a concern for proprietary software projects, making participant performance as a dependent variable in the research model would provide insights of more interest to the industry. Hence, this research enriches the literature on empowerment's effect on individuals' behavior outcomes in general and in the OSS communities in particular, and its findings can serve as guidelines for proprietary software projects. The results of the present study indicate that, different from what was hypothesized, autonomy and meaningfulness have negative effects on performance. Future researchers are urged to further investigate these two empowerment components' effects and find possible contingent factors that may affect their influences on performance.

Third, this study enriches the literature on empowerment's effects on performance. Although it is well established that empowerment has a positive effect on performance [47], [63], [65], [67], [70], [71], the literature has been mute about the influencing process of empowerment. According to motivation theories, motivational constructs, including empowerment, affect the behavior outcomes through effort, a process variable (e.g., [7], [39], and [41]). Thus, by examining the mediating role played by effort, this paper extends our understanding of how empowerment affects performance. Also, by studying the effects empowerment's components (i.e., autonomy, competence, meaningfulness, and impact), this research unveils how these components have differential effects on performance and, in particular, how their effects are mediated by effort expended on the task. Hence it helps to resolve the controversial findings in the extant literature.

C. Managerial Implications

Our study has practical implications for the management of both open source and proprietary software development and in other work contexts that rely on voluntary engagement of participants, such as diffusion of knowledge management systems. In particular, the feelings of competence have significant effects on participation outcomes. As such, project leaders should find ways to maximize participants' sense of competence. For example, the project leader may adopt a modular design approach and make tasks fine-grained. Such a task design would allow participants to take up a small task at a time, which requires

relatively less time and skills than a large complex task. Therefore, it may enhance individuals feeling of competence and motivate them to remain engaged and expend effort on the project.

In addition, the sense of making impact is another empowerment component that has positive effects on individual performance in OSS projects. Hence, project leaders should make participants well aware of what impacts they are making on the project and how they can contribute to the project. For instance, the project leaders can make the evaluation system more transparent. In other words, the project leaders can have newsletters distributed within the group showing who contributes what to the project and acknowledging those participants who make significant impacts.

Furthermore, practitioners should be aware that empowerment may influence performance through effort. As such, it is critical to ensure that participants exert their effort to the greatest capacity when they work on the project. For example, project leaders can offer support to individuals when they encounter difficulties so that participants would remain engaged, rather than quit from the project.

APPENDIX I

MEASUREMENT INSTRUMENT

Empowerment: Meaningfulness (Adapted from [65])	EM_MEAN1	1. Participating in this project is very important to me.
	EM_MEAN2	2. My activities in this project are personally meaningful to me.
	EM_MEAN3	3. My participation in this project is meaningful to me.
Empowerment: Competence (Adapted from [65])	EM_CMP1	4. I am confident about my ability to contribute to this project.
		5. I am self-assured about my capabilities to perform my activities in this
	EM_CMP2	project.
	EM_CMP3	6. I have mastered the skills necessary for participating in this project.
Empowerment: Autonomy (Adapted from [65])		7. I have significant autonomy in determining how I contribute to this
	EM_AUTO1	project.
	EM_AUTO2	8. I can decide what tasks to take on in this project.
	EM_AUTO3	9. I have the freedom to decide how I participate in this project.
Empowerment: Impact (Adapted from [65])	EM_IMP1	10. My impact on what I do in this project is large.
	EM_IMP2	11. I have control over what happens in this project.
	EM_IMP3	12. I have influence over what happens in the project.
Effort: Time Commitment (Adapted from [76])	TIME_CM1	1. I work long hours on this project.
	TIME_CM2	2. I have devoted a large number of hours to this project.
	TIME_CM3	3. I put in more hours than most of my peers in this group.
Effort: Task Persistence (Adapted from [76])	TASK_PST1	5. I overcome obstacles to complete tasks in this project.
	TASK_PST2	6. I enthusiastically tackle difficult problems in this project.
	TASK_PST3	7. When the task is difficult, I make every effort to complete it.
Effort: Effort Intensity (Adapted from [76])	EFF_1	9. When I work on this project, I do so with intensity.
	EFF_2	10. I work at my full capacity when I work on tasks in this project.
	EFF_3	11. I strive as hard as I can when I work on this project.
	EFF_4	12. When I work on this project, I put in my best effort.
Perceived Performance (Adapted from [72])	TASK_PRF1	1. My contribution to this project is higher than the average in this group.
	TASK_PRF2	2. The quality of my contribution is higher than the average in this group.
		3. My efficiency of working on this project is much higher than the
	TASK_PRF3	average in this group.

APPENDIX II

FURTHER DATA ANALYSIS RESULTS

The second-order construct of empowerment is treated as a reflective construct with the measures of the latent variable scores of its four dimensions. Fig. 3 summarizes the empirical model that is analyzed with PLS-Graph 3.00. None of the control variables is significant. The R^2 for performance is 0.46. Also, all links are significant at the level of $p < 0.001$.

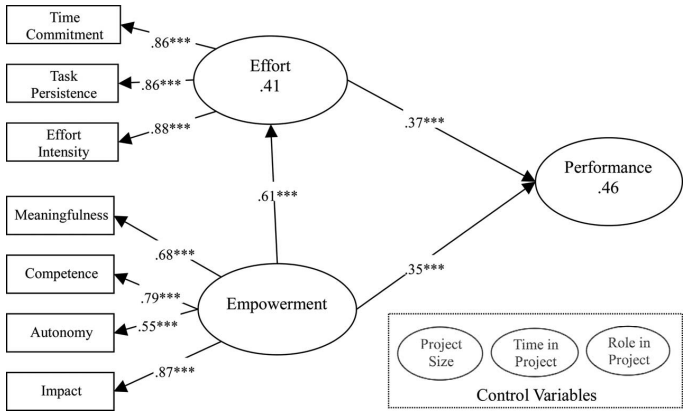

Fig. 3. Empirical model ($***p < 0.001$).

To investigate the mediating effects of effort on the association of empowerment, as a second-order construct, and performance, we follow the three-step procedure [6]. When effort is not in the model, the coefficient of the link between empowerment and performance is 0.60 coefficient. As indicated in Fig. 3, the coefficient between empowerment and performance decreased to 0.35 when effort is introduced as a mediator. Furthermore, the variances explained for performance was greatly increased in the model with effort being controlled (0.46 versus 0.37). Therefore, effort partially mediates empowerment's effect on performance and empowerment has both direct and indirect effects on performance.

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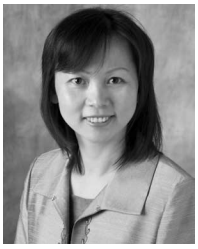
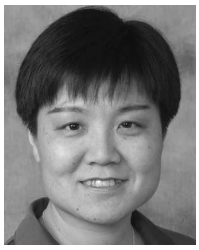


Weiling Ke received the Ph.D. degree from the National University of Singapore, Singapore.

She is currently an Associate Professor of operations and information systems in the School of Business, Clarkson University, Potsdam, NY. Her current research interests include enterprise systems, open source software, and electronic commerce. She is an Associate Editor for *AIS Transactions of Human Computer Interaction*. She has authored or coauthored the *Journal of Operations Management*, the *Journal of the Association for Information Systems*, *Personnel Psychology*, *Communications of the ACM*, *Decision Support Systems*, *International Journal of Electronic Commerce*, and other IS journals.



Ping Zhang received the Ph.D. degree from the University of Texas at Austin.

She is currently a Professor in the School of Information Studies, Syracuse University, Syracuse, NY. Her current research interests include human-centeredness in information and communication technology (ICT) development, evaluation and use; affective, cognitive, motivational, and behavioral aspects of individual reactions toward ICT; and the impact of ICT design and use on individuals, organizations, societies, and cultures. She is a coeditor (with Dennis Galletta) of two edited books on HCI and MIS of the Advances in MIS series (by M. E. Sharpe, 2006), and is a coauthor (with Dov Te'eni and Jane Carey) of the first HCI textbook for non-CS students (by John Wiley, 2007). She and D. Galletta are founding Editors-in-Chief for AIS Transactions on Human–Computer Interaction. In addition, she is a Senior Editor for JAIS, former Associate Editor for *International Journal of Human Computer Studies* (IJHCS) and Communications of the Association for Information Systems, and a Guest Senior Editor of seven special issues for journals such as *Journal of the Association for Information Systems, Journal of Management Information Systems, International Journal of Human Computer Studies, International Journal of Human-Computer Interaction*, and *Behaviour and Information Technology*.

Dr. Zhang has received four Best Paper awards, three nominations for the best paper awards, an excellence in teaching award, and an outstanding service award.