

# MOTIVATIONS FOR PARTICIPATING IN OPEN SOURCE SOFTWARE COMMUNITIES: ROLES OF PSYCHOLOGICAL NEEDS AND ALTRUISM

Ke, Weiling, Clarkson University, Clarkson Ave., Potsdam, NY 13676, USA,  
wke@clarkson.edu

Zhang, Ping, Syracuse University, School of Information Studies, 328 Hinds, Syracuse,  
NY 13244, pzhang@syr.edu

## Abstract

*As a new phenomenon of the software industry, Open Source Software (OSS) development has attracted many research interests. Examining what motivate participants to be involved in OSS projects is one of the recently heated research areas. This study is motivated by the significance but lacking evidence on how personality traits may affect participants' task effort on OSS projects. In particular, we investigate how personality traits namely psychological needs for autonomy and competence, and one's altruism interact with motivations. Following Self-Determination Theory, we differentiate different types of. In addition, drawing upon the Affective Event theory, we submit that personality traits moderate the relationships between task effort and both external and identified motivations. The research model is largely supported by data from 204 participants in various OSS projects. Theoretical contributions and practical implications are discussed.*

*Keywords: open source software development, motivation, personality traits, task effort*

## 1 INTRODUCTION

The recent decades have witnessed the success of Open Source Software (OSS) development (von Krogh and von Hippel 2006). Major companies such as IBM and Sun Microsystems, and large venture capitalists are investing generously in these communities. In the meantime, questions of how and why this new model works have become great interest to researchers (Lee and Cole, 2003; von Krogh and von Hippel, 2006). Realizing that the success of these communities largely relies on participants' effort and contributions, investigating what drives participants to be involved in these communities is essential and of great significance (Franke and von Hippel, 2003; Hars and Ou, 2002; Hertel, et al., 2003; Kuk, 2006; Lakhani, et al., 2002; Lerner and Tirole, 2002).

The extant literature has identified the following factors as motivating factors: enjoyment of cognitive challenges of programming, developing software that is not available in the market,

signaling competence to potential employers, identification with the project groups and the belief in the ideology of OSS movement (Bagozzi and Dholakia, 2006; Bonaccorsi, et al., 2006; Roberts, et al., 2006; Shah, 2006). These motivations energize participants to expend effort on OSS projects. Yet, motivation theories largely posit that motivations can be influenced by personality traits (Deci and Ryan 2000; Ryan and Deci 2000). To date, the existing studies on OSS have neglected the interaction effects of motivations and personality traits. As such, investigating possible contingency on which these motivations drive participants to expend effort in OSS communities can extend our current wisdom and, probably, provides more meaningful guidance for OSS project management.

In this research, we investigate moderating effects of personality traits, namely psychological needs for competence and autonomy, and altruism, on the relationships between motivations and task effort. We consider one type of task effort, effort intensity, as the focus of the study. Effort intensity in the OSS context is defined as the energy exerted per unit of time when an individual is participating in an OSS project. Drawing upon Self-Determination Theory (SDT) (Deci and Ryan, 1985; Deci and Ryan, 2000; Ryan and Deci, 2000), we categorize the motivating factors in OSS communities into intrinsic, integrated, identified, and external motivations. We then examine the contingency effects of an individual's psychological needs and altruistic orientation on the relationships between effort intensity and both external and identified motivations. The research model is tested with data collected from 204 OSS participants and is largely supported.

## 2 THEORETICAL BACKGROUND AND RESEARCH MODEL

Motivation plays a central role in the field of performance management (Steers, et al., 2004). Indeed, motivation theories are widely used to study performance (Locke and Latham, 2004). There are many definitions of motivation in the extant literature. For example, Atkinson defines motivation as “the contemporary (immediate) influence on direction, vigor and persistence of action” (Atkinson, 1964, p.2), while Locke and Latham (2004) define motivation as “internal factors that impel action and the external factors that can act as inducements to action (Locke and Latham 2004, p. 388). These definitions are principally concerned with factors or events that energize, channel, and sustain human behaviors over time and eventually lead to task performance and well-being (Steers et al. 2004).

In the extant literature, many theories have been put forth to explain an individual's motivations (Kanfer, 1991; Pinder, 1998). For example, Vroom (Vroom, 1964) presented the first systematic formulation of expectancy theory and (Locke and Latham, 1990) proposed a theory of goal setting that links goal specificity, goal difficulty, and goal commitment to enhanced task performance. Most of the existing motivation theories make meaningful contributions to our understanding of what is obviously a complex process. However, motivation theories treat motivation as a unitary concept (Meyer, et al., 2004).

According to SDT, motivation is not a unitary or bipolar construct (Deci and Ryan 2000; Ryan and Deci 2000). Instead, based on the degree of regulation internalized, motivation is a

spectrum consisting of intrinsic motivation, integrated, identified, introjected and external motivation (Deci and Ryan 2000). Intrinsic motivation refers to the motivation to engage in a behavior primarily for its own sake, because the behavior itself is engaging, interesting or in some way satisfying. In contrast, with an external motivation (i.e., extrinsic motivation as in other motivation theories), an individual acts with the intention of obtaining a desired consequence or avoiding an undesired one, so he or she is energized into action only when the action is instrumental to those ends. An individual may internalize the external motivation by taking in values and transforming the external regulation of a behavior into an internal regulation. Thus, the individual no longer requires the presence of an external contingency (Ryan and Deci 2000; Meyer et al. 2004). Based on the degree to which an external regulation is internalized, Deci and Ryan (2000) categorize them into introjected, identified and integrated extrinsic motivations (Ryan and Deci 2000; Gagne and Deci 2005). When introjected, a regulation has been taken in by an individual but has not been accepted as his or her own. When identified, a person feels greater freedom and volition because the behavior is more congruent with their personal goals and identities. When integrated, an individual has a full sense that the behavior is an integral part of who he or she is, that it emanates from the sense of self and is thus self-determined.

In the context of OSS communities, there exist different types of motivations and they affect individual participation differently (Ke and Zhang, 2008. Roberts et al. 2006). Therefore, in order to provide a detailed true picture of the impact of motivation, it is critical to treat these motivations as a spectrum of motivation as suggested by SDT. Previous research has found a number of motivating factors in OSS communities. These factors include the need for software that is not available in the market, signalling competence to potential employers, recognition by peers in the community, seeking for cognitive challenge and enjoyment of programming, identifying with the project group and strong belief in OSS ideology (Franke and von Hippel, 2003; Hars and Ou, 2002; Hertel, et al., 2003; Bagozzi and Dholakia, 2006; Bonaccorsi, et al., 2006; Roberts, et al., 2006; Shah, 2006) These motivating factors fall into the spectrum of motivation suggested by SDT. In particular, need for software, signalling competence to potential employers and gaining reputation among peers are external motivations; seeking for challenge and enjoyment is intrinsic motivation; identification with the group is identified extrinsic motivation; and ideology conviction is integrated extrinsic motivation. Since participation in the OSS communities is fully discretionary, individuals do not have to comply with others' order. As such, it is unlikely to see the presence of introjected extrinsic motivation in OSS communities. According to SDT, motivations reflect intentions to act and energize and sustain individual behaviors over time (Deci and Ryan 2000). As such, motivations have positive influences on task effort. Indeed, the positive effects of motivations on task effort in OSS communities have gained empirical support (Ke and Zhang 2008).

Built on the existing findings, this study further investigates how the effectiveness of different types of motivations is contingent upon personality traits such as individual psychological needs and altruism. There are two psychological needs that may interact with an individual's motivations in the OSS context, namely the need for competence and the need for autonomy (Deci and Ryan 2000). Need for autonomy (Ryan and Deci 2000) is a need that all humans

have, to some extent, representing the need to be self-determining or self-initiating. Need for competence represents an individual's desire to achieve success through one's own efforts and to take personal responsibility and credit for outcomes. The strength of individuals' psychological need varies. Satisfaction of these psychological needs is essential for human development (Ryan et al. 1996) and for positive behaviors (Hackman and Lawler, 1974). In addition, altruism can play an important role in affecting an individual's conducting behaviors that benefit others, such as developing open source software. Altruism refers to interpersonal helping and includes discretionary behaviors that assist another person with an organizationally relevant task or problem (Konovsky and Pugh, 1994). Therefore, it is appropriate to explore how psychological needs and altruism affect the relationships between motivations and task effort intensity.

In particular, we focus on the interaction effects of external motivation and personality traits, and of identification motivation and personality traits. Figure 1 depicts our research model.

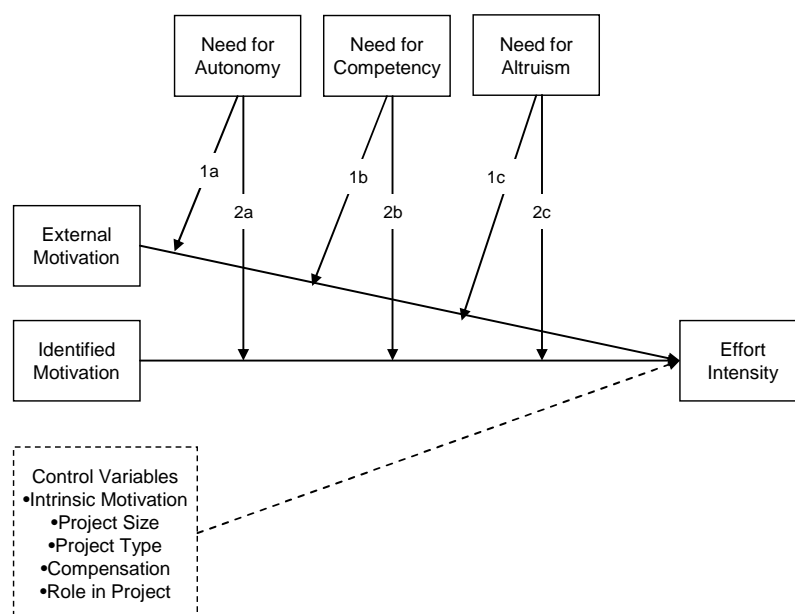


Figure 1. The Research Model

A broad literature has demonstrated the importance of ongoing feelings of autonomy and competence for optimal functioning and well-being. According to affective event theory (Weiss and Cropanzano, 1996), affective events that bring positive feelings of autonomy and competence thus satisfy these psychological needs can influence an individual's behavior in general and discretionary behavior in particular (Ilies et al. 2006; Lee and Allen 2002). Stated alternatively, when an individual experiences more positive affective states and has higher psychological satisfaction, he or she will exert more effort on conducting behaviors that are not mandated.

In the context of OSS, participating and making contribution to the project is a discretionary behavior, similar to organizational citizen behavior, and thus is directly influenced by affective events (Weiss and Cropanzano 1996). Also, in OSS communities, need for autonomy is readily satisfied since participants have the freedom to choose what to contribute and how to contribute to

an OSS project. Similarly, OSS project groups continuously improve software and constantly share knowledge and thus provide a channel to satisfy an individual's need for competence. As such, a participant's need for competence and autonomy will moderate external motivation's effect on effort intensity in the OSS context. External motivation is aroused by an individual's desire to seek for instrumental gains such as financial reward and reputation; it energizes effort that does not satisfy psychological needs directly (Deci and Ryan 2000). However, the context of OSS communities readily satisfies participants' psychological needs and therefore can strengthen external motivation's influence on effort intensity (Ilies, et al., 2006). Specifically, given the same level of external motivation, an individual with a higher need for competence and autonomy will have a higher level of effort intensity on an OSS project. Hence, we hypothesize the following:

*Hypothesis 1a An individual's psychological need for autonomy strengthens the relationship between external motivation and effort intensity in an OSS project.*

*Hypothesis 1b An individual's psychological need for competence strengthens the relationship between external motivation and effort intensity in an OSS project.*

With an altruistic orientation, an individual gains satisfaction from helping others or conducting behaviors whose outcomes benefit others. Such positive affective feelings may reinforce the effects of external motivation on the individuals' effort expended on the task. Specifically, when an individual is energized to work on a task solely by his or her external motivation, he or she is focused on the outcomes rather than the process. However, if the individual has a psychological orientation toward altruism, performing tasks that benefit other will allow him or her to experience positive affect about what is being done. As such, the individual will appreciate and enjoy the process, and enhance his or her task effort. Given that OSS enhances other users' and developers' well being, in addition to bringing possible instrumental outcomes for a participant, altruism will affect the relationship between external motivation and effort intensity. In particular, with the same level of external motivation, a higher level of altruism may enable the individual to experience more positive affective feelings and thus inspire the individual to exert fuller effort on the task. Hence, we hypothesize the following:

*Hypothesis 1c An individual's altruism strengthens the relationship between external motivation and effort intensity in an OSS project.*

The reasoning for the psychological needs' moderating effects can be extended to the relationship between identified motivation and effort intensity in an OSS project. Specifically, when an individual has a strong psychological need for competence and autonomy, he or she will seek to improve competency and value self-determination, respectively. Pursuing the goal of the group and/or conducting the tasks agreed upon by the group may not be able to satisfy the individual's need for competence and autonomy efficiently and directly. As such, the individual will work more independently rather than exerting great effort on conducting the behavior chosen by the group, which is the consequence of identified motivation. Therefore, when an individual has a strong need for competence or need for autonomy, the positive effect of identified motivation on effort intensity on participating in OSS development may be diminished. Hence, we hypothesize the following:

*Hypothesis 2a An individual's psychological need for autonomy mitigates the relationship between identified motivation and effort intensity in an OSS project.*

*Hypothesis 2b An individual's psychological need for competence mitigates the relationship between identified motivation and effort intensity in an OSS project.*

With an identified motivation, an individual is mobilized to perform tasks that benefits the group, the so-called “in-group favoritism” (Bagozzi and Lee 2002). Without considering altruism, the individual may be simultaneously expecting others in the group to share the norms of reciprocity and be supportive also (Bagozzi and Dholakia 2006). With an altruistic orientation, an individual will perform the tasks that benefit others without expecting for return. That is, altruism allows the individual to remain engaged in the group activities even though his or her peers are not reciprocating. As such, given the same level of identified motivation, a higher level of altruism will lead an individual to work more intensively on the OSS development tasks. Hence, we hypothesize the following:

*Hypothesis 2c An individual's altruism strengthens the relationship between identified motivation and effort intensity in an OSS project.*

To account for as much as possible the differences among individual participants, we also consider the effects of five control variables. One control variable is individual motivation, i.e., intrinsic motivation. This type of motivation's positive effect on participants' task effort in OSS communities is supported by empirical studies (e.g., Ke and Zhang 2008). The other four control variables are pertinent to the context and characteristics of the OSS projects. These variables include project team size, product type, whether the participant is compensated and the primary role played by the participants in a project. We select these variables because they may have an impact on task effort expended on the project, although investigation of these variables' effects is scant in the extant literature.

### **3. RESEARCH METHODOLOGY**

#### **3.1 Data Collection**

To test our research model, we conducted a survey to collect data from OSS project participants. We randomly selected our respondents from the discussion forums hosted by sourceforge.net and some other on-line forums such as MySQL and OpenOffice. We sent out about 2000 invitations and asked the respondents to fill out our questionnaires posted through SurveyMonkey, an online survey service provider. A total of 225 people responded to our invitations. Among returned questionnaires, 17 were incomplete and were discarded. We tested the non-response bias by the method suggested by Armstrong and Overton (Armstrong and Overton, 1977). That is, we compared the chi-squares of the responses from the first 25% of the respondents to that of the final 25%. A significant difference would indicate the presence of non-response bias. Our results showed that there was no non-response bias.

### **3.2 Measures of the Constructs**

The measurement items in our questionnaire were adapted from existing validated and well-tested scales in the extant literature. These scales had been proved to have good validity and reliability. In the questionnaire, Effort intensity, four types of motivations, and altruism were treated as reflective variables to be consistent with the literature. They were measured with 5-point Likert scales, ranging from “strongly disagree” to “strongly agree.” We also provided the choice of “not applicable” for these variables. Effort intensity was measured by items adapted from Yeo and Neal (Yeo and Neal, 2004). The instruments for external and identified motivation were adapted from Amabile et al. (Amabile, et al., 1994) and Allen and Meyer (Allen and Meyer, 1996), respectively. The measurement scales for altruism were adapted from Konovsky and Pugh (1994).

The measurement scales for psychological need (i.e., need for autonomy and competence) were adapted from Rei et al. (Reis, et al., 2000). Psychological needs variables were treated as formative variables. The instrument consists of specific questions and specific ways of calculating the scores. For the need for autonomy, three daily activities were asked to be listed and four reasons of doing them were asked to be rated with a scale from 1 to 5. The calculated score for the need for autonomy is the average of the three activities’ scores, where each is a weighted aggregation of the four measures (with the weigh of -2, -1, 1, 2 respectively for the four items). The measure for the need for competency is the average of the scores for rating (from 1 to 5) how effective in doing each of the three activities. For the four control variables that are specific to the particular OSS project situations, we used the direct answers for roles played, product types, and compensation, and converted answers into discrete categorical values.

## **4. DATA ANALYSES AND RESULTS**

There were two stages for data analyses. In the first stage, we assessed the reliability and construct validity of the reflective variables using confirmatory factor analysis. In the second stage, we conducted multi-regression analyses with SPSS to examine the moderating effects of personality traits on the effects of external and identified motivations on effort intensity.

### **4.1 Measurement model**

The confirmatory factor analysis showed that the loadings of all measurement items of reflective variables in the last column were higher than the benchmark of 0.7 (Barclay et al. 1995; Chin 1998). Convergent validity and discriminant validity were used to examine the measurement scales (Hair et al. 1998). Convergent validity was assessed by (1) reliability of items, (2) composite reliability of constructs, and (3) average variance extracted (AVE) (Fornell et al. 1981; Werts et al. 1974). Reliability of items was assessed by each item’s loading on its corresponding construct. Table 1 shows the composite reliability (CR) of each reflective construct. It is recommended that CR should be .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 (Chin 1998). It is recommended that it should exceed .50. Table 3 shows the AVEs of all constructs exceeded .50. Hence, all three conditions for convergent validity were met.

Discriminant validity between constructs was assessed using Fornell and Larcker's recommendation that the square root of the AVE for each construct should exceed the correlations between this construct and all the other constructs (Chin 1998; Fornell et al. 1981). In Table 1, the shaded numbers on the diagonals are the square root of the AVEs. Off-diagonal elements are the correlations among constructs. All diagonal numbers are much greater than the corresponding off-diagonal ones, indicating satisfactory discriminant validity of all the constructs.

Table 1. Internal Consistency and Discriminant Validity of Constructs								
	Constructs	CR	AVE	1	2	3	4	5
1	Effort Intensity	0.90	0.75	0.87				
2	Identified Motivation	0.91	0.63	0.38***	0.79			
3	External Motivation	0.82	0.60	0.23**	0.18*	0.77		
4	Intrinsic motivation	0.87	0.68	0.20**	0.15*	0.17*	0.82	
5	Altruism	0.81	0.69	0.05	0.14	-0.11	0.07	0.83

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

## 4.2 Hypotheses Testing

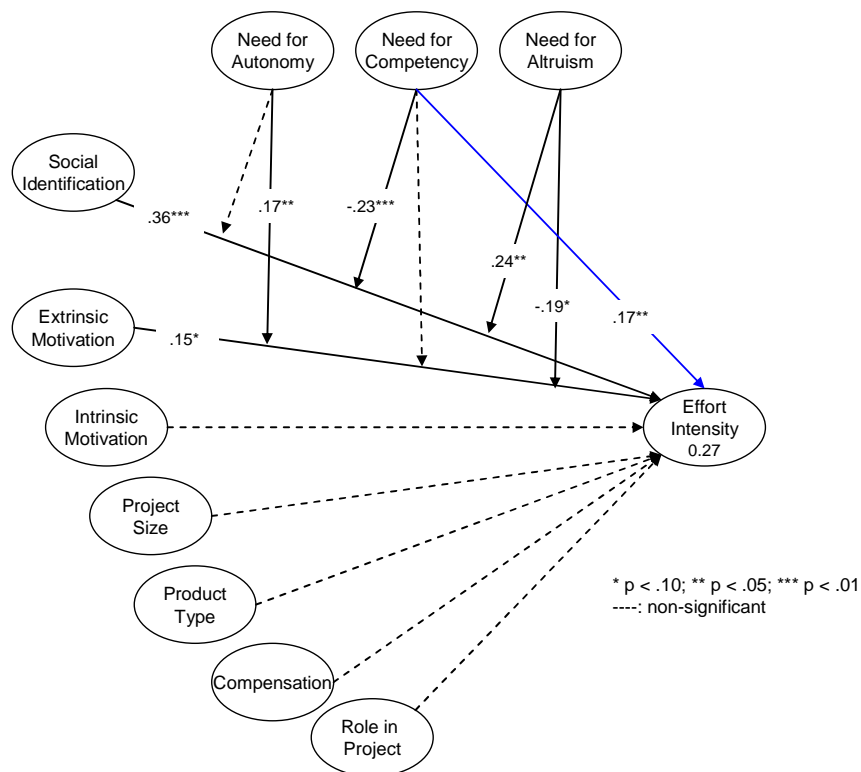


Figure 2. The Empirical Model

A series of three multi-regressions were conducted. Model 1 has only control variables as the antecedents of effort intensity. Model 2 has the control variables and external and identified motivations as the antecedents. Model 3 has all the above variables and the moderators. As

shown in Table 2, Model 2's result indicated that, without taking personality traits into consideration, intrinsic and identified motivations were significantly related to effort intensity. In contrast, external motivation was not significant. However, the result of Model 3 (with personality traits and moderators) showed that external motivation had a positive effect on effort intensity, while intrinsic motivation's effect became insignificant. In addition, Model 3 provided significantly higher variances explained than the other two models and supported four out of six hypotheses. Specifically, the term of the multiplication of external motivation and need for autonomy was significant ( $b=0.172$ ,  $p=0.039$ ). Hypothesis 1a on the positive moderating effect of need for autonomy on the external motivation-effort intensity relationship is supported. The multiplication of external motivation and altruism was also significant ( $b=-0.19$ ,  $p=0.062$ ), which supports our hypothesis 1c, but in the opposite direction. Our Hypothesis 2b on the negative moderating effect of need for competence on the identified motivation-effort intensity relationship is supported ( $b=-0.225$ ,  $p=0.015$ ). In addition, the results support Hypothesis 2c which proposed the positive moderating effect of altruism on the relationship between identified motivation and effort intensity. Figure 2 summarizes the hypotheses testing results.

## 5. DISCUSSIONS AND CONCLUSION

The current paper investigates the interaction effects of OSS participants' motivations and personality traits on their effort intensity. Specifically, rather than treating motivation as a unitary construct, we differentiate motivations along the spectrum proposed by self-determination theory (Deci and Ryan 2000; Ryan and Deci 2000). We assess how these different types of motivations' effects on effort intensity are moderated by individual personality traits namely psychological need for autonomy and competence, and altruistic orientation. In particular, we focus on personality traits' effects on the relationships between effort intensity and both external and identified motivation. Our research model is largely supported by the empirical data. Our results indicate that external motivation's positive effect on OSS participants' effort intensity is strengthened by their need for autonomy and mitigated by altruistic orientation. The latter finding is to the contrary of what we hypothesize. A possible explanation is that altruism allows participants to enjoy the process of contributing to OSS projects and such enjoyment may distract their focus from reaching the goal and realizing the instrumental outcomes. We appeal that studies further investigate the interaction effect of external motivation and altruism and verify the validity of our finding on the surprising negative relationship. Also, our results show that participants' need for competence mitigates the effect of identified motivation on effort intensity, while altruism strengthens the identified motivation-effort intensity relationship.

It is important to evaluate this study's results and contributions in light of its limitations. First of all, we collected data with a single source during one period of time. All the major constructs were measured by respondents' perceptions, which are subjective. Future research should use some objective measures from multiple sources. Ideally, future research should also collect data at multiple points in time. A longitudinal study may enrich research findings by offering additional information on the possible variations of the relationships between

independent and dependent variables within a person across time and how the fluctuations of a person's psychological needs moderate the relationships. Second, we collected data with English-speaking OSS participants. OSS development, as a global phenomenon, involves individuals speaking various languages and with diverse national cultures. Future research should be conducted to verify the applicability of our research results to participants speaking different languages and of different cultures.

This research makes two major theoretical contributions. First, this study enriches our understanding of the effects of different types of motivation on effort intensity. Our results, consistent with self-determination theory, indicate that these effects vary across different types of motivation. Therefore, our research lends credibility to SDT theory and empirically validates that motivation is not a unitary construct. Second, we extend the OSS participation research to incorporate the effects of personality traits. Personality traits play a critical role in affecting individuals' behaviors, beliefs and values. Given that there is no organizational control and formal remunerating systems in the OSS communities, personality traits are expected to be even more important in guiding individuals' self-organization. Indeed, as indicated by our research findings, models with and without personality traits provide different information about which motivation is a significant antecedent of effort intensity. As such, without incorporating personality traits in the model, a research studying factors affecting individual's volitional behaviors may get spurious or misleading results. Unfortunately, there is a dearth of research investigating the effects of personality traits in the OSS context. As far as we are aware, this study is the first study that examines the effects of personality traits on the relationships between motivations and effort intensity in the OSS context. As such, the current study opens up avenues for research investigating the confluence of motivation and personality traits in OSS communities.

This study also has significant practical implications. Specifically, OSS project leaders should be aware of the effects of personality traits on how motivations energize participants' effort. Currently, project leaders may focus on the technical competence of participants and assign tasks to participants accordingly. Our research suggests that personality traits affect how hard a participant will work on the tasks. In particular, psychological needs for autonomy and altruism make external motivation have an even greater impact on effort intensity. It shows that, when the project leaders are offering inducements, they should provide participants of such personality traits with more opportunities to self-determine what to work on and how to proceed. In contrast, our research demonstrates that need for competence makes identified motivation less effective in mobilizing participants' effort. This finding suggests that project leaders should assign cognitively challenging tasks to participants with high identified motivation and provide them with facilitating resources so that the participant can derive more satisfaction from participating in group activities.

## REFERENCES

Allen, N.J., and Meyer, J.P. "Affective, continuance, and normative commitment to the organization: An examination of construct validity," *Journal of Vocational Behavior*

- (49:3), 1996, pp. 252-276.
- Amabile, T.M., Hill, K.G., Hennessey, B.A., and Tighe, E.M. "The Work Preference Inventory - Assessing Intrinsic and Extrinsic Motivational Orientations," *Journal of Personality and Social Psychology* (66:5), 1994, pp. 950-967.
- Armstrong, J.s., and Overton, T.S. "Estimating nonresponse bias in mail surveys," *Journal of Marketing Research* (14:3), 1977, pp. 396-402.
- Atkinson, J.W. *An introduction to motivation*, Van Nostrand, Princeton, 1964.
- Bagozzi, R.P., and Dholakia, U.M. "Open source software user communities: A study of participation in Linux user groups," *Management Science* (52:7), 2006, pp. 1099-1115.
- Bagozzi, R.P. and Lee, K.H. "Multiple Routs for Social Influence: The role of compliance, internalization, social identity," *Social Psychology Quarterly*, (65:3), 2000, pp. 226-247.
- Barclay, D., Higgins, C., and Thompson, R. "The Partial Least Squares (PLS) Approach to Causal Modeling, Personal Computer Adoption and Use as an Illustration," *Technology Studies* (2:2) 1995, pp 285-309.
- Bonaccorsi, A., Giannangeli, S., and Rossi, C. "Entry strategies under competing standards: Hybrid business models in the open source software industry," *Management Science* (52:7), 2006, pp. 1085-1098.
- Chin, W.W. "The Partial Least Squares Approach to Structural Equation Modeling," in: *Modern Methods for Business Research*, G.A. Marcoulides (ed.), Lawrence Erlbaum Associates, Mahwah, NJ, 1998, pp. 295-336.
- Deci, E.L., and Ryan, R.M. *Intrinsic Motivation and Self-determination in Human Behavior*, Plenum, New York, 1985.
- Deci, E.L., and Ryan, R.M. "The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior," *Psychological Inquiry* (11:4), 2000, pp. 227-268.
- Fornell, C., and Larcker, D.F. "Structural Equation Models With Unobservable Variables and Measurement Errors," *Journal of Marketing Research* (18:2) 1981, pp 39-50.
- Franke, N., and von Hippel, E. "Satisfying heterogeneous user needs via innovation toolkits: the case of Apache security software," *Research Policy* (32:7), 2003, pp. 1199-1215.
- Gefen, D. "Customer loyalty in e-commerce," *Journal of the Association for Information Systems* (3) 2002, pp 27-51.
- Hackman, J.R., and Lawler, E.E., III. "Employee reactions to job characteristics," *Journal of Applied Psychology Monograph* (55), 1974, pp. 259-285.
- Hair, J.F., Anderson, R.E., Tatham, R.L., and Black, W.C. *Multivariate Data Analysis* Prentice Hall, Englewood Cliffs, NJ, 1998.
- Hars, A., and Ou, S.S. "Working for free? Motivations for participating in open-source projects," *International Journal of Electronic Commerce* (6:3), 2002, pp. 25-39.
- Hertel, G., Niedner, S., and Herrmann, S. "Motivation of software developers in Open Source projects: an Internet-based survey of contributors to the Linux kernel," *Research Policy* (32:7), 2003, pp. 1159-1177.
- Ilies, R., Scott, B.A., and Judge, T.A. "The interactive effects of personal traits and experienced states on intraindividual patterns of citizenship behavior," *Academy of Management Journal* (49:3), 2006, pp. 561-575.
- Kanfer, R. "Motivation theory and industrial and organizational psychology," In *Handbook of industrial and organizational psychology*, M. D. Dunnette and L. M. Hough (eds.),

- Consulting Psychologists Press, Palo Alto, CA, 1991,
- Ke, W. and Zhang, P. " Motivations in OSS Communities: The Mediating Role of Effort Intensity and Goal Commitment," Working Paper 2008.
- Konovsky, M.A., and Pugh, S.D. "Citizenship Behavior and Social-Exchange," *Academy of Management Journal* (37:3), 1994, pp. 656-669.
- Kuk, G. "Strategic interaction and knowledge sharing in the KDE developer mailing list," *Management Science* (52:7), 2006, pp. 1031-1042.
- Lakhani, K.R., Wolf, R.G., and Bates, J. "The Boston Consulting Group Hacker Survey, Release 0.3,"), 2002,
- Lee, G.K., and Cole, R.E. "From a firm-based to a community-based model of knowledge creation: The case of the Linux kernel development," *Organization Science* (14:6), 2003, pp. 633-649.
- Lerner, J., and Tirole, J. "Some simple economics of open source," *Journal of Industrial Economics* (50:2), 2002, pp. 197-234.
- Locke, E.A., and Latham, G.P. *A theory of goal setting and task performance*, Prentice-Hall, Englewood Cliffs, NJ, 1990.
- Locke, E.A., and Latham, G.P. "What should we do about motivation theory? Six recommendations for the twenty-first century," *Academy of Management Review* (29:3), 2004, pp. 388-403.
- Meyer, J.P., Becker, T.E., and Vandenberghe, C. "Employee commitment and motivation: a conceptual analysis and integrative model," *Journal of Applied Psychology* (89:6), 2004, pp. 991-1007.
- Pinder, C.C. *Work Motivation in Organizational Behavior*, Prentice Hall, Upper Saddle River, NJ, 1998.
- Reis, H.T., Sheldon, K.M., Gable, S.L., Roscoe, J., and Ryan, R.M. "Daily well-being: The role of autonomy, competence, and relatedness," *Personality and Social Psychology Bulletin* (26:4), 2000, pp. 419-435.
- Roberts, J.A., Hann, I.H., and Slaughter, S.A. "Understanding the motivations, participation, and performance of open source software developers: A longitudinal study of the Apache projects," *Management Science* (52:7), 2006, pp. 984-999.
- Ryan, R.M., and Deci, E.L. "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being," *The American Psychologist* (55:1), 2000, pp. 68-78.
- Shah, S.K. "Motivation, governance, and the viability of hybrid forms in open source software development," *Management Science* (52:7), 2006, pp. 1000-1014.
- Steers, R.M., Mowday, R.T., and Shapiro, D.L. "Introduction to Special Topic Forum - The Future of Work Motivation Theory," *Academy of Management Review* (29:3), 2004, pp. 379-387.
- von Krogh, G., and von Hippel, E. "The promise of research on open source software," *Management Science* (52:7), 2006, pp. 975-983.
- Vroom, V.H. *Work and motivation*, Wiley, New York, 1964.
- Weiss, H.M., and Cropanzano, R. "Affective events theory: a theoretical discussion of the structure, causes, and consequences of affective experiences at work," In *Research in Organizational Behavior*, 18, 1996, pp. 1-74.

- Werts, C.E., Linn, R.L., and Jöreskog, K.G. "Intraclass Reliability Estimates: Testing Structural Assumptions," *Educational and Psychological Measurement* (34) 1974, pp 25-33.
- Yeo, G.B., and Neal, A. "A multilevel analysis of effort, practice, and performance: Effects of ability, conscientiousness, and goal orientation," *Journal of Applied Psychology* (89:2), 2004, pp. 231-247.