

Knowledge sharing in open source software communities: motivations and management

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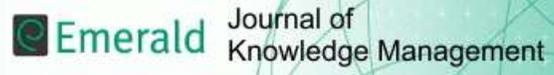
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**Knowledge Sharing in Open Source Software Communities:
Motivations and Management**

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Knowledge Sharing in Open Source Software Communities: Motivations and Management

Introduction

The effective management of knowledge is a primary concern for organisations seeking to compete in the contemporary economic environment (Grant, 1996). Consequently, knowledge management strategies have become widespread (Hislop, 2013; Davenport and Prusak, 1998; Nonaka and Takeuchi, 1995; *inter alia*). Knowledge management may be defined as ‘any process or practice of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to enhance learning and performance in organisations’ (Scarborough *et al.*, 1999, p. 1). Knowledge sharing is, then, central to knowledge management practices (Renzl, 2008; Cabrera and Cabrera, 2005). In the process of sharing, knowledge is not only distributed but also transformed in the act of articulation, interpretation, and absorption. Knowledge sharing therefore contributes to the creation of new knowledge (Nonaka and Takeuchi, 1995). Consequently, knowledge sharing has attracted significant research attention (Li *et al.*, 2014; Faraj *et al.*, 2011; Ruuska and Vartiainen, 2005; *inter alia*). Despite the benefits of sharing knowledge there are barriers that prevent its free flow, for example, within organisations individuals may have incentives to hoard or hide knowledge (Michailova and Husted, 2003; Connelly *et al.*, 2012).

Open Source Software (OSS) communities have been identified as exemplars of knowledge sharing. In such knowledge-intensive non-commercial environments individuals appear to share their knowledge freely with other community members in order to develop new and improved software products (Rolandsson *et al.*, 2011; von Krogh and von Hippel, 2003; Raymond, 1999; *inter alia*). OSS communities, in which the software source code is freely available to those who wish to collaborate to solve a particular programming problem, involve many participants interacting with each other online. Hence, OSS communities provide an excellent context within which to investigate knowledge sharing in online organisations.

The success of knowledge sharing in OSS communities is apparent in the development of OSS tools and utilities, including *Linux Operating System*, *Apache HTTP Server*, *MySQL Database*, *PHP Web Development Language* - known as the *LAMP* stack for web servers, and the *Firefox* web browser. These products compete with their commercial counterparts in software markets. The success of these communities gives rise to various questions including: How do they facilitate knowledge sharing? And, what can commercial organisations learn from them about knowledge sharing? Much research attention has focused on what motivates members to participate and share knowledge in online communities (Wasko and Faraj, 2000; Bergquist and Ljungberg, 2001; Maki-Komsi *et al.*, 2005). Yet, little attention has been devoted to understanding how the management of such communities may influence members’ willingness to participate and thereby share their knowledge. Consequently, through an empirical investigation of OSS developers specialising in web development this article explores both how the motivations of individual participants influence their level of knowledge sharing and how such motivations are affected by the quality of the OSS community’s management.

The article begins by briefly reviewing the literature on knowledge sharing before focusing on the factors stimulating knowledge sharing in online communities. The management of OSS communities is briefly considered and it is hypothesised that the quality of management

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3 influences the extent to which the motivations of participants actually result in the sharing of
4 knowledge. The research methods are then briefly elaborated before the findings are reported.
5 The implications of the findings for knowledge sharing in OSS projects and online
6 communities more generally are discussed and the limitations of the study are noted. The
7 article ends with brief concluding comments, including directions for future research.
8

9 **Literature review: knowledge sharing in OSS communities**

10 *Knowledge sharing in organisations*

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14 Knowledge is an important organisational resource (Grant, 1996). However, as Luring and
15 Selmer (2012) note, its links to social structures make it is difficult to manage. An
16 appreciation of knowledge sharing in organisations requires an understanding of the nature of
17 knowledge. In the organisational context, knowledge is often defined as the application and
18 productive use of information. Yet, knowledge is more than information, since it involves an
19 awareness or understanding gained through experience, familiarity or learning. At a personal
20 level, knowledge requires a relation between the ‘knowing self’ and the external world.
21 Knowing is an active process that is mediated, situated, provisional, pragmatic and contested
22 (Blackler, 1995). It involves cognitive structures that can assimilate information and put it
23 into a wider context, allowing actions to be undertaken from it (Howells and Roberts, 2000).
24 Furthermore, in some instances and respects knowledge may be individually centred, while in
25 others it may be collectively held (Spender, 1996). Indeed, knowledge may be held in
26 sophisticated information and communications technology (ICT) facilitated knowledge
27 repositories (Davenport and Prusak, 1998), embedded in the routines and practices of
28 organisations (Nelson and Winter, 1982), or situated in the communities that form around
29 specific organisational practices (Wenger *et al.*, 2002).
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33 Whether knowledge is tacit or explicit influences the ease with which it may be shared. Tacit
34 knowledge is non-codified knowledge that is acquired via the informal take-up of learning
35 behaviour and procedures (Howells, 1996); it is often referred to as know-how. Explicit
36 knowledge may be transferred across time and space embodied in codified tangible forms,
37 such as training and operations manuals, software, and patents. Through the process of
38 codification, knowledge is reduced to information that can be transformed into knowledge by
39 those individuals who have access to the appropriate code or framework of analysis. For the
40 individual, it is necessary to make an initial irreversible investment to acquire the relevant
41 code (Arrow, 1974). In a sense, ‘knowledge is a retrieval structure: the agents possessing a
42 certain type of knowledge can retrieve both information based on this knowledge and other,
43 similar, pieces of knowledge’ (Saviotti, 1998, p. 848). Importantly, such a retrieval structure
44 may be made up of both explicit and tacit knowledge.
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48 Knowledge is rarely completely codified. Even explicit codified knowledge must be tacitly
49 understood (Polanyi, 1967). If a body of knowledge contains a significant tacit element, the
50 exchange of the codified part alone may fail to facilitate successful knowledge sharing
51 (Roberts 2001). Tacit knowledge is difficult to fully articulate and it is therefore more time
52 consuming to acquire. Sharing such knowledge may involve a process of demonstration and
53 learning by doing (Roberts 2000; Arrow, 1974). As a result, tacitness gives knowledge a
54 sticky quality (Szulanski, 1996; von Hippel, 1994).
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57 Whatever the nature of knowledge, an important determinant of successful knowledge sharing
58 will be the capacities of the individuals involved in the process. The original possessor of the
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3 knowledge must be able to articulate the knowledge to facilitate its externalisation and the
4 recipient must be able to internalise the knowledge, that is, they must have an appropriate
5 level of absorptive capacity (Cohen and Levinthal, 1990).
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8 Organisational knowledge sharing takes place at various levels, from the individual to the
9 group and across departments and divisions (Ipe, 2003). Knowledge sharing also reaches
10 across organisational boundaries. At each of these levels, the role of the individual is essential
11 for knowledge ultimately resides with the individual (Polanyi, 1967). Moreover, as Nonaka
12 and Takeuchi (1995) argue, individual knowledge sharing is central to the creative process.
13 Consequently, the ability of an organisation's members to share knowledge influences the
14 speed of new product development (Renzl, 2008), and ultimately has a significant impact on
15 organisational performance. Understanding the dynamics of knowledge sharing at the level of
16 the individual is therefore of central importance to the development of successful knowledge
17 management strategies (Cabrera and Cabrera, 2005). Ipe (2003), for example, identifies four
18 core factors influencing knowledge sharing among individuals, namely, the nature of
19 knowledge, the motivations to share, the opportunities to share, and the culture of the work
20 environment.
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22
23 Knowledge sharing requires the active engagement of individuals in a process of interaction
24 and learning (Roberts, 2000). Consequently, understanding what motivates individuals to
25 participate in knowledge sharing will support the design of successful knowledge
26 management strategies. Moreover, a collaborative culture and opportunities to share
27 knowledge in the work environment will directly affect the individual's knowledge sharing
28 activity. These conditions can be influenced by management practices. A wide range of
29 academic studies explores knowledge sharing in organisations. For instance, Witherspoon *et*
30 *al.*, (2013) investigates the antecedents of organisational knowledge sharing, Young (2014)
31 examines knowledge sharing intention in knowledge management systems, and Amayah
32 (2013) explores the determinants of knowledge sharing in a public sector organisation.
33 Studies that include a focus on management and governance include Chuang *et al.*'s (2015)
34 examination of factors influencing middle management employees' knowledge sharing
35 intentions, and Huang *et al.*'s (2013) assessment of the mediating roles of motivation on
36 knowledge governance mechanisms. More broadly, Cabrera and Cabrera (2005) identify the
37 socio-psychological determinants of knowledge sharing, including social ties and shared
38 language, trust, group identification, perceived cost, perceived rewards, self-efficacy, and
39 expectations of reciprocity. Their findings suggest that people management practices focused
40 on work design, staffing, training and development, performance appraisal, compensation,
41 culture, and technology can support knowledge sharing (Cabrera and Cabrera, 2005).
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46 Although much knowledge is shared between co-located individuals, it is increasingly the
47 case that creative activity is geographically distributed, whether in the globally dispersed
48 research and development units of large companies or in online communities (Amin and
49 Roberts, 2008). Since the rise of the Internet, a growing number of online communities have
50 emerged in which knowledge is created and shared by individuals working voluntarily in
51 informal self-organising virtual structures (Roberts, 2014; Prasarnphanich and Wagner, 2011;
52 Baytiyeh and Pfaffman, 2010). In online communities, codified knowledge is shared
53 electronically. The codified knowledge of expert communities may be highly specialised and
54 require a significant amount of individual tacit knowledge for it to be interpreted, absorbed,
55 and employed by recipients. Understanding knowledge sharing in spatially dispersed
56 communities in which individuals communicate with one another through frequent online
57 communications is of growing importance. Based on an exploration of a distributed work
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3 environment, Maki-Komsi *et al.* (2005) suggest that factors contributing to successful
4 knowledge sharing include: communication of the required information, support for informal
5 learning based on colleagues' practical experiences, shared work practices within the team or
6 community, right group membership, group members' attitudes towards knowledge sharing,
7 openness towards knowledge sharing, feeling of community with remote colleagues,
8 voluntary participation in the knowledge sharing activities, shared responsibility for sharing
9 knowledge, agility of the tools in use, and good team leadership coordinating the
10 communication. Additionally Faraj *et al.* (2011) argue that knowledge sharing in online
11 communities is aided by the presence of the tensions among five resources: passion, time,
12 ambiguous social identity, social disembodiment of ideas, and temporary convergence. The
13 combinations of such resources reveal themselves in the strength of an individual's
14 motivation to share knowledge.
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16 17 *Motivations to share knowledge in OSS communities* 18

19 Ipe (2003) identifies internal and external factors that influence an individual's motivation to
20 share knowledge. Internal factors include the perceived power attached to knowledge and
21 reciprocity arising from sharing knowledge, and external factors relate to relationships with
22 recipients and the rewards arising from sharing knowledge. Connected to these factors is the
23 value of knowledge to the individual and to the organisation (Prasarnphanich and Wagner,
24 2011; Chang and Chuang, 2011; *inter alia*). Indeed, knowledge hoarding may result when
25 exclusive access to certain knowledge gives individuals status within the organisation
26 (Connelly *et al.*, 2012; Michailova and Husted, 2003). The value of knowledge in relation to
27 competition between organisational members also raises the issue of trust between workers
28 and management. For instance, Renzl (2008) finds that trust in management encourages
29 knowledge sharing by reducing an individual's fear of losing their unique value, while
30 Connelly *et al.* (2012) find that employees do not share knowledge with those they distrust.
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34 These findings are equally relevant to knowledge sharing in online communities. An
35 additional consideration for such communities is the availability of an appropriate information
36 technology (IT) infrastructure. Distributed community members must be able to connect to
37 and use electronic networks if they are to share knowledge (Huysman and Wulf, 2006).
38 Hence, their motivations are only effective when technological tools enable the
39 communication that is required to share knowledge. The technological tools available to
40 members of an OSS community are now standardised involving email and online forums as
41 well as databases that retain earlier electronic exchanges and versions of the software code at
42 various stages of its development. Importantly, such infrastructure requires appropriate
43 management to facilitate the smooth, reliable, and ongoing communications between
44 community members.
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47 Individual members' contributions to an online community are not always an addition to the
48 community's knowledge base. However, the exchanges between members often lead to
49 creative engagement and in this way to the collaborative development of new knowledge. In
50 an OSS community, this new knowledge takes the form of a development in the software at
51 the centre of a project. An appreciation of what motivates individuals to contribute to such
52 communities provides a basis for understanding knowledge sharing behaviour and offers
53 insights into how to stimulate more effective and frequent knowledge sharing with positive
54 outcomes for creativity in online communities and organisations more broadly (Chiu *et al.*,
55 2006).
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3 Much research has focused on the motivations underpinning knowledge sharing in OSS
4 communities. Lead-users are particularly active in contributing to software developments and
5 thereby encouraging knowledge sharing because of their desire to influence product
6 development (Jeppesen and Laursen, 2009). Bergquist and Ljungberg (2001) draw
7 comparisons between knowledge sharing in online communities and in academia where
8 individuals share knowledge, not only for altruistic reasons, but also because it is an accepted
9 requirement of career progression within this field. Based on the findings of a study of three
10 Usenet technical communities, Wasko and Faraj (2000) argue that people collaborate and
11 shared knowledge in the expectation of tangible and intangible returns. Tangible benefits
12 include, for instance, an answer to a technical problem, and intangible reasons comprise,
13 meeting like-minded individuals, learning from solutions offered, peer recognition, a moral
14 obligation to help others in a common technical community, maintaining standards, and
15 spreading ideas.
16

17
18 Bonaccorsi and Rossi (2003) and Ulhoi (2004) have identified five broad types of motives for
19 sharing knowledge in OSS communities, namely, economic, psychological, social,
20 intellectual, and technological. Economic drivers can relate to monetary rewards following
21 the completion of a project or gaining a reputation among peers with future career benefits.
22 Improved value of skills, feeling of solidarity, feeling of altruism and efficiency, and
23 reputation are among the psychological drivers. Social drivers include social prestige,
24 expectation of reciprocity, fun of programming, sense of belonging to the community, and the
25 fight against proprietary software. Aesthetic qualities, individual needs, and learning
26 opportunity are intellectual drivers. Working with “cutting-edge technology” is a
27 technological driver. More specifically, Aalbers (2004) identifies three core motives for
28 sharing knowledge in OSS communities, namely, self-enriching, group-enriching, and
29 knowledge-enriching. Although many studies identify the two key motivations as intrinsic
30 and extrinsic (Mikkonen *et al.*, 2007), beyond this there is a general lack of consensus on the
31 core factors influencing motivations for knowledge sharing in online communities.
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35 An extensive review of the available literature undertaken for this research suggest that the
36 motivations underpinning knowledge sharing in OSS communities can be grouped into seven
37 core types, namely, hobbies, philosophical factors, accomplishments, altruism, network
38 opportunities, personal needs and main work needs. Table 1 summarises the literature on the
39 motivations driving knowledge sharing in OSS communities. However, motivations alone do
40 not ensure successful knowledge sharing. Management can have an important impact
41 facilitating an organisational context that is conducive to knowledge sharing, for example, by
42 providing appropriate rewards, encouraging a trusting environment, providing robust
43 technology, and good leadership. Consequently, attention now turns to the role of
44 management in online communities and OSS projects to assess its influence on knowledge
45 sharing.
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50 Insert Table 1 about here
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53 *Management in OSS communities*

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55 As online communities grow and mature, they required systems of coordination just like any
56 other organisation (Chua and Yeow, 2010). Contrary to popular perceptions of self-
57 management, the large OSS communities have highly developed systems of coordination and
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3 control – or management – centred on core and peripheral teams with frequent interaction
4 between the two. The coordination structure and roles in OSS communities have been traced
5 in a number of studies (Chua and Yeow, 2010; Jensen and Scacchi, 2007; *inter alia*). The
6 findings of such research suggest a sophisticated division of labour with positions of authority
7 determined by competence. According to Schmidt and Porter (2001) in OSS communities,
8 core developers are responsible for activities such as the inspection of the software
9 architectural integrity, fixing mistakes and track day-to-day progress, whereas periphery
10 developers test and debug the software released periodically. Indeed, Madanmohan and
11 Navelkar (2002) describe the following six roles with specific knowledge management
12 responsibilities in online communities: Core Organiser, who organises the community,
13 initiates discussions and groups formations; Expert, who shares her/his tacit knowledge;
14 Problem poser, who brings problems and poses queries; Implementer/Bug reporter, who
15 establishes the practical validity of the suggestions made, and reports limitations/bugs;
16 Integrator, who brings together several rules and/or suggestions, and builds the project's
17 taxonomy/manual; and, finally, Institutionaliser, who push for standardisation and regulatory
18 support. Importantly, unlike traditional hierarchical organisations where roles and rewards are
19 formally fixed, in online communities role behaviour is flexible (Madanmohan and Navelkar,
20 2002), allowing talented members of the periphery to move easily into the core.

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24 The distribution of responsibilities in OSS projects can be depicted in the form of an “onion”
25 with passive users and/or observers at the outer layer, and active users, developers, project
26 managers and community managers being progressively closer to the centre and, core
27 developers at the very heart of the community (Jensen and Scacchi, 2007). Four methods of
28 role acquisition can be identified in OSS communities: implicitly by performing a task;
29 earned and granted by a body of authority; elected to a position by the community or a sub-
30 committee; and, appointment by an individual or body of authority (Jensen and Scacchi,
31 2007).

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34 According to Raymond (1999), any software project management has five functions: to
35 identify aims/goals and coordinate activity so that everybody keeps progressing in the same
36 direction, to monitor to ensure that details are not skipped, to motivate people to do boring but
37 necessary work, to organise contributors to maximise productivity, and to secure the
38 resources necessary for the project. The success of OSS projects requires not only the
39 effective management of people and the securing resources, but as Asklund and Bendix
40 (2001) note, tools and processes must also be managed. Technical tools, such as servers, are
41 vital for OSS development because the codes of all software versions and bug fixes must be
42 stored. The importance of technological tools and software platforms for interaction in OSS
43 communities necessitates active management (Metiu and Kogut, 2001). Even when
44 technology is managed well its limitations in terms of knowledge sharing must recognised.
45 For instance, excellent online communication tools cannot alone facilitate the transmission of
46 tacit knowledge (Roberts, 2000).

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48
49 Given the voluntary nature of contributions to OSS projects, the social aspects of the
50 community can have an important impact on members' motivations to participate and share
51 knowledge (Bonaccorsi and Rossi, 2003; Ulhoi, 2004). Consequently, creating a socially
52 rewarding atmosphere that is conducive to knowledge sharing among contributors is an
53 important task for the management of geographically dispersed online communities.

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56 The management of OSS communities is essential to coordinate the collaborative efforts of
57 geographically dispersed voluntary contributors to achieve one goal efficiently. Yet, few
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3 studies of OSS communities consider how members' satisfaction with management
4 influences the success of a project and the motivations of individuals to share their
5 knowledge. Nevertheless, Agterberg *et al.* (2010) suggest that the environments in which they
6 occur influence community members' knowledge sharing activities. Management can
7 therefore influence knowledge sharing by exerting control over community content and
8 connections through designing and maintaining an appropriate organisational infrastructure
9 (Agterberg *et al.*, 2010). Members' satisfaction with management in online communities can
10 be influenced by the attributes of the people involved and levels of trust present in the
11 community (Staples and Ratnasingham, 1998; Shin, 2004). Nevertheless, management in an
12 OSS project can slow software developments and become a bottleneck if it delays the
13 dissemination and use of a newly developed application (Asklund and Bendix, 2001).
14
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16 The contributions of individual members are important to the success of OSS communities.
17 As extant research reveals, members' motivations are underpinned by a variety of factors
18 (Table 1). Yet, highly motivated members alone do not ensure a community's success. Other
19 factors are required to enable members' motivations to be fully harnessed to accomplish the
20 community's goals. In particular, the appropriate management of people and resources within
21 an OSS community is vital to promote the efficient organisation of community members'
22 efforts and to ensure that members' motivations to share knowledge are realised. Without
23 appropriate management members' motivations can be dampened by, for example, the
24 frustrations that can be caused by a poor communication infrastructure, inadequate
25 technological support, lack of reward in the form of recognition, or a negative, distrustful
26 social culture. Hence, the management of an OSS community can influence its members'
27 motivations to share knowledge. Although motivations to contribute to OSS communities
28 derive from the individual's characteristics, these motivations are moderated by the quality of
29 the management. It can therefore be hypothesised that: *The higher the quality of management*
30 *the stronger will be the individual's motivations to share knowledge in OSS projects.*
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34 **Research methods**

35
36 To test the hypothesis outlined in the previous section, it was necessary to gather data on the
37 relevant variables, namely members' satisfaction with management as an indicator of the
38 quality of management, the strength of individual's motivations and the extent to which
39 individuals share knowledge in the OSS community. The research adopted a quantitative
40 approach with data collected through the use of an online questionnaire survey (see Appendix
41 1). The questionnaire design drew on previous studies identified through the review of
42 literature. Following a pilot study with ten OSS developers, the questionnaire was reviewed
43 and revised to correct the weaknesses identified prior to its widespread distribution. Although
44 different from the real respondents, the participants in the pilot study were comparable to
45 members of the population from which the real sample was drawn (Bryman and Bell, 2003).
46 The main survey employed a dedicated webpage through which the respondents' data was
47 automatically compiled into a database. The data collection process was designed to maintain
48 respondents' anonymity in line with ethical research practices. During the period from 21st
49 May 2007 to 31st July 2007, 275 email exchanges were undertaken with individuals,
50 communities (through online discussion boards/forums), and groups of people related to OSS
51 development to solicit participation in the survey. By the end of July 2007, 142 respondents
52 had completed the questionnaire. Due to significant amounts of missing data, five responses
53 were excluded, giving a total of 137 responses available for the data analysis.
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3 Although the scale of the OSS community is unknown, an indication of its size was gained
4 from SourceForge.net, which is one of the world's largest OSS development websites. In the
5 summer of 2007, it hosted more than 142 thousands projects and had nearly 1.5 million
6 registered users. Given the lack of complete information on the total population of OSS
7 community members, it was not possible to calculate the appropriate sample size as
8 recommended by Sekaran (2003). However, Roscoe (1975) suggests that a sample size larger
9 than 30 and less than 500 is appropriate for most research and that in multivariate research the
10 sample size preferably should be 10 times as large as the number of variables. A frequently
11 used formula to calculate sample size is $N > 50 + 8m$, where 'm' is the number of independent
12 variables (Tabachnick and Fidell, 2007; Pallant, 2007). This study sought to maximise the
13 sample size and the number of responses obtained meets the parameters necessary to ensure
14 reliable results.
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16
17 Factor analysis was implemented to identify the variables required to test the hypothesis, and
18 to checking the data for reliability. Variables were identified by grouping appropriate
19 questions together from the questionnaire as shown in Table 2. The Cronbach's Alpha for
20 most variables considered in this study were higher than 0.8 and a few of them were higher
21 than 0.7 (Table 2). Additionally the Component Matrix was >0.5 indicating high internal
22 consistency and reliability (Sekaran, 2003).
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26 Insert Table 2 about here
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30 An independent variable 'KNOWLEDGE SHARING', was created by employing three
31 questions from the questionnaire that were connected with one meaning – the respondent's
32 view of their knowledge sharing in OSS communities. These questions concerned the
33 following: 1) the individuals' frequency of communication with members of the community
34 (FREQ COM); 2) the hours per week spend sharing knowledge in the OSS project (HOURS
35 PER WK); and, 3) the percentage of the respondents' participation related to project
36 development in the OSS community (% PART PROJ DEV). Factor analysis revealed that the
37 cumulative percentage of variance accounted for by all these factors is equal to 65%. Hence,
38 through factor analysis it was possible to employ these three questions to construct the
39 variable 'KNOWLEDGE SHARING', with a Cronbach's Alpha equal to .818.
40

41
42 As an indicator of the quality of management, a moderating variable 'SATISFACTION
43 WITH MANAGEMENT' was created by employing a set of six questions concerning
44 respondents' view of management to produce one variable through factor analysis (see Table
45 2). Drawing from an analysis of the relevant literature (see for example, Amaratunga and
46 Baldry, 2002; Macbryde and Mendibil, 2003; and Mikkonen *et al.*, 2007) as well as
47 discussions with individuals involved in OSS development projects, the questions employed a
48 5-point interval scale labelled either from 'very satisfied' to 'very dissatisfied' or from 5
49 'strongly agree' to 1 'strongly disagree'. The Cronbach's Alpha for the moderating variable
50 constructed through this process was equal to .862.
51

52
53 A dependent variable 'MOTIVATIONS' was created by employing a 5-point Likert-type
54 scale (5 - 'strongly agree' to 1 - 'strongly disagree') in a set of questions designed to assess the
55 strength of each motivation identified from the literature (see Table 1). By a dependent
56 variable 'MOTIVATIONS' we mean a set of seven variables - "Hobby", "Altruism",
57 "Accomplishment", "Philosophical Factors", "Network Opportunities", "Personal Needs",
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and “Main Work Needs” (Table 2). It is therefore possible to analyse the importance of different types of motivations for knowledge sharing in relation to levels of satisfaction with management. The Cronbach’s Alpha for the various components of ‘MOTIVATIONS’ ranged from .721 - .878.

Following an analysis of the descriptive data, correlation analysis was employed to explore the relationship between the variables in the hypothesis. The analysis was extended through the application of regression analysis. The data analysis was facilitated by the use of SPSS (Statistical Package for the Social Sciences), with guidance from Pallant (2007) and Hair *et al.*, (2007).

Results

Descriptive data analysis

The geographical distribution of the questionnaire respondents centred predominantly on the advanced western nations. The largest portion of the respondents derived from the USA (35.77%), with the UK being the second largest source (24.82%), of the remaining respondents 21.90% were from other European countries, 3.65% were from Australia, 2.19% were from New Zealand, and 2.92% were from Canada. The rest of the world accounted for the remaining 8.75% of respondents.

Almost 98% of the questionnaire respondents were male and the majority of these were under 30 years of age. Respondents were distributed among age ranges as follows: 51.82% aged 20-29; 22.63% aged 30-39; 8.76% aged 40-49; 2.19% aged 50-59; less than 1% aged 60-69; and, 6.57% aged under 19. Over 80% of the respondents were younger than 40. Combining the geographical location and age of the respondents, it is interesting to note that countries other than the UK and USA, had a higher proportion of younger contributors. The sample of respondents from the USA was characterised by greater age diversity than those of other countries. The primary occupation of the majority of the respondents was either an IT employee (35.48%) or IT - self-employed (32.26%). Of the remaining respondents, 18.06% were students, 6.45% were in employment other than IT, and 7.75% were retired or engaged in other activities. Although the data confirmed the existence of a hierarchy within the OSS community, members predominantly engage with their peers (47.3% of the respondents), with only 36.94% of the respondents making contact with forum/project moderators, and 15.77% of the respondents making contact with top management teams.

To summarise, the questionnaire respondents were predominantly young males with extensive IT knowledge and they derived largely from English speaking countries, especially the USA and the UK. These characteristics conform to those of OSS communities members identified in other studies (see for example, Jensen & Scacchi, 2007).

Correlation analysis

Pearson’s correlation analysis was employed to investigate the strength of relationships between knowledge sharing, motivations and satisfaction with management in OSS communities. As evident from Table 3, these variables are positively correlated. Most importantly, the correlation analysis demonstrates that management has positive relationships with five out of seven motivations: philosophical factors (.305**), accomplishment (.262**), altruism (.367**), network opportunities (.310**), personal needs (.393**). These results

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3 suggest that management can positively influences the motivations of OSS community
4 members. Additionally, satisfaction with management is positively correlated with
5 knowledge sharing (.213*), suggesting that knowledge sharing is associated with the
6 successful management practices. Furthermore, individual sources of motivation have
7 positive and often significant association with each other (Table 3). For instance,
8 accomplishment as a motivation has positive relationships with other motivations such as
9 hobby (.218*) and philosophical factors (.295**), while altruism has positive relations with
10 philosophical factors (.380**) and accomplishment (.758**), and personal needs have
11 positive relations with philosophical factors (.623**), accomplishment (.504**), altruism
12 (.555**), and network opportunities (.532**).
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16 Insert Table 3 about here
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18

19 *Regression analysis*

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21 To investigate further the relationship between knowledge sharing, motivations and
22 satisfaction with management in OSS communities hierarchical multiple regression analysis
23 was undertaken to explore the multiple relationships between the variables (Table 4a-c). In
24 this analysis, the independent variable (predictor), which needs to be controlled for, was
25 entered into the regression in the first stage. The moderating variable, whose relationship was
26 to be examined, was entered in the second stage. The analyses confirmed the reliability of the
27 data, for instance, the indicator of the significant F showed very low levels (Table 4b)
28 (Pallant, 2007). The results of the multiple regression analysis show that satisfaction with
29 management plays a significant role influencing the strength of contributor's motivations. At
30 each stage in the hierarchical multiple regression analysis, an additional term is added in order
31 to calculate the change in R^2 . A hypothesis is tested based on whether the change in R^2 is
32 significantly different from zero. In our analysis, R^2 is different from zero and the change in
33 R^2 from Model 1 to Model 2 is not large, which means that the value is significant (Table 4a-
34 b).
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38 Interestingly, hobby and main work needs do not show a significant relationships with
39 knowledge sharing and satisfaction with management ($b=.081$, $t=.776$, ns) and ($b=.164$,
40 $t=1.582$, ns) respectively (Table 4c). These results may be explained by the particular
41 attitudes of individuals whose main motivations for contributing to the OSS community are
42 based on a hobby or main work needs, in the sense that these individuals may be less sensitive
43 to the quality of management; they will contribute even when they are less satisfied with
44 management than members whose other motivations are stronger. In contrast, all other
45 motivations were found to be dependent on satisfaction with management: altruism ($b=.339$,
46 $t=3.566$, $p<.001$ **), personal needs ($b=.380$, $t=4.298$, $p<.000$ ***), philosophical factors
47 ($b=.301$, $t=3.097$, $p<.003$ **), accomplishment ($b=.251$, $t=2.529$, $p<.013$ *), and network
48 opportunities ($b=.310$, $t=3.154$, $p<.002$ ** (Table 4c). Additional analysis was undertaken to
49 explore the influence of respondents' age on the connection between knowledge sharing,
50 motivations and satisfaction with management. Two age ranges – one below 30 years and the
51 other above 30 years - were analysed. The results for both age ranges were consistent with
52 those of the main analysis indicating that motivations to share knowledge did not vary with
53 age.
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3 The data analysis suggests that satisfaction with management plays an essential role
4 increasing the strength of OSS contributor's motivations. Consequently, satisfaction with
5 management influences the level of knowledge sharing in OSS communities as a whole. Only
6 hobby and main work needs do not show a significant relationship with satisfaction with
7 management.
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10 Insert Table 4 about here
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12 Discussion

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15 The findings support the view that the management of geographically dispersed online
16 communities plays a crucial role in creating an environment for OSS community members
17 that is conducive to knowledge sharing. Good management therefore contributes to the
18 success of the OSS communities. In particular, members' satisfaction with management
19 influences the realisation of individual motivations to share knowledge. The results of this
20 study supports the current academic literature (Metiu and Kogut, 2001; Asklund and Bendix,
21 2001; Van Den Hooff and Huysman, 2009; *inter alia*), by showing the importance of well-
22 organised management for successful knowledge sharing between OSS community members.
23 Moreover, the findings confirm the hypothesis identified earlier by suggest that the quality of
24 management in OSS communities is an essential factor strengthening an individual's
25 motivations to share knowledge in OSS projects.
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29 Clearly, the activities of the leaders and managers of OSS communities, and managers of
30 organisations in general, can play an important role supporting knowledge sharing processes
31 within their communities and organisations. For instance, by promoting an amenable
32 environment, managers may facilitate the full realisation of personal motivations and thereby
33 enhance knowledge sharing. By paying attention to the factors that motive community
34 members, and aligning their management practices to take account of such motivations,
35 managers can support higher levels of knowledge sharing, thereby increasing the speed of
36 new products and services development (Renzl, 2008).
37

38
39 However, the findings of this study suggest that the factors that motivate community
40 members differ and that different motivations have different sensitivities to the quality if
41 management. Hence, where OSS community members' motivations are based on a hobby or
42 main work needs, they are less sensitive to the quality of management when compared to
43 others whose motivations derive from other sources. OSS community managers would benefit
44 from understanding the source of motivations of their members, as this will allow scarce
45 managerial resources to be directed towards supporting those members whose motivations are
46 more likely to be dampened by low levels of satisfaction with management.
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49 Although motivations to contribute in OSS development are important for knowledge sharing,
50 as Agterberg *et al.* (2010) found in their study of geographically distributed inter
51 organisational networks, organisational factors, including management, are the key to keeping
52 online communities alive, productive, and looking forward to further innovations. While OSS
53 communities may emerge spontaneously from a mutual interest in a particular programming
54 problem, for such communities to develop and thrive over time management systems are
55 necessary to support individual participants and ensure that their levels of motivations are
56 sustained over time. Leaders and managers of OSS communities can do much to encourage
57 knowledge sharing and to strengthen the individual's level of motivation. As in the non-
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3 virtual world, managers of OSS communities can promote knowledge sharing through the
4 development of favourable technological, cultural, and organisational environments within
5 which community members can develop their own knowledge through sharing and interacting
6 with others in the process of OSS development. These insights have relevance beyond the
7 OSS community as organisations of all sorts are seeking to harness the voluntary
8 contributions of workers, supplier, and customers to support their knowledge sharing
9 strategies both in online and real world communities
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12 Knowledge sharing is one of the most challenging issues in the management of knowledge.
13 Yet in OSS communities, individual members need to share their knowledge in order to
14 engage in the activities of the community. By investigating knowledge sharing and how
15 satisfaction with management influences the motivations to share knowledge in the specific
16 example of OSS communities, the findings of this study provide an original contribute to the
17 current academic literature on knowledge management and, in particular, the connections
18 between individual members' satisfaction with management and motivations to share
19 knowledge in the OSS community. This adds to knowledge of the complexity of motivations
20 and suggests that appropriate management can enhance knowledge sharing in OSS
21 communities.
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24 Nevertheless, the research has some limitations. According to Podsakoff *et al.* (2003), method
25 biases are one of the main sources of measurement error. Potential sources of method biases
26 are common rate effects, item characteristic effects, item context effects and measurement
27 context effects. The online questionnaire was designed with a careful consideration of
28 problematic factors such as obtaining measures of the predictor and criterion variables from
29 different sources, protecting respondent anonymity to reduce evaluation apprehension,
30 counterbalancing the question order and improving scale items. However, there still can be a
31 bias of 'measurement context effects' present in the nature of the work which corresponds to
32 any artifactual covariation formed from the context, where the measures are obtained
33 (Podsakoff *et al.*, 2003).
34

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36 In addition, this research was conducted via a cross-sectional study, which can be considered
37 as one of the potential biases. According to Bozionelos (2002), causal path modelling is a
38 useful technique for the well-designed description of the relationships between variables.
39 Such modelling was used in this research during the regression analysis. However, these types
40 of design do not allow "causality assertions", because "causality in cross-sectional research
41 can be only speculated and tentatively accepted; and needs to be further substantiated with
42 utilization of the other research designs" (Bozionelos, 2002, p. 7). According to Bozionelos
43 (2002, p. 7), when cross-sectional designs are "utilized certainty on causality is seriously
44 compromised, regardless of the way authors choose to present their findings".
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48 There are also limitations resulting from the size of the sample used in this research. Even
49 though the sample size in the quantitative data collection can be regarded as reliable, the
50 findings would be strengthened if there were more observations. For future research the
51 sample size could be improved by attending major OSS conferences and distributing the
52 questionnaire for completion to the conference delegates. Finally, because the empirical data
53 was collected in 2007, it is important to recognise that the OSS community and its members
54 may have changed thereby undermining the relevance of the findings presented here.
55 Nevertheless, the analysis of the data has produced findings that are consistent with recent
56 studies considered in the review of literature.
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Conclusions

Understanding the dynamics of knowledge sharing is an issue of central concern to managers of knowledge intensive organisations including online communities (Faraj *et al.*, 2011; Ruuska and Vartiainen, 2005; Van Den Hooff and Huysman, 2009; *inter alia*). How the management of online communities can influence the knowledge sharing activities of members is poorly appreciated (Metiu and Kogut, 2001; Asklund and Bendix, 2001; Van Den Hooff and Huysman, 2009). Consequently, this article has sought to shed light on the relationship between the quality of OSS community management, individual members' various motivations, and levels of knowledge sharing.

Although there has been much research directed towards identifying the factors that motivate OSS community members to engage in knowledge sharing, little attention has been devoted to understanding how management may influence the motivations identified. The findings of this empirical study suggest that the members' motivations do affect the level of knowledge sharing in OSS communities, but that members' satisfaction with management is also important in determining the level of knowledge sharing. From the perspective of the individuals surveyed, the analysis suggests that successful knowledge sharing is facilitated by high levels of satisfaction with OSS community management in combination with individuals' motivations to share knowledge, rather than only individuals' motivations to share knowledge. Consequently, knowledge sharing in OSS communities is facilitated through the appropriate management of members and resources, including processes and IT infrastructures.

The findings of this study reveal that there are differences between community members according to the source of their motivations and such differences influence the extent to which the quality of management can enhance levels of knowledge sharing. Recognising and adapting to the variations in members' sources of motivation to share knowledge is something that would benefit both online voluntary communities and commercial organisations. Understanding the differences in the sources of members' motivations, and how management practices need to be adapted to such differences would be valuable. Furthermore, there are many different types of OSS communities, large well-known ones such as PHP, MySQL and Apache and small recently created ones. Understanding how managerial requirements vary according to the size and stage of development of the OSS community would also be useful. This article has provided fresh insights into the motivations stimulating knowledge sharing in OSS web development projects and the impact of management on these motivations. Nevertheless, there is scope for further research to uncover the full complexity of knowledge sharing deriving from voluntary contributions in online communities and organisations more broadly.

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Appendix: Extract from the online questionnaire

(Due to space restrictions this table includes only questions that were used to test the hypothesis. The full questionnaire is available on request from the corresponding author.)

A) Personal details

1. Your gender is: M F Prefer not to say
2. Your age is:
3. You are from:
4. Your highest education attainment is:
- PhD Master level (MSc, MA, MBA) Undergraduate level High school graduation
- Other, please specify
5. Do you have any professional qualifications? No Yes, please specify
6. Your primary occupation is: (please indicate all that apply)
- IT Employee IT, Self-Employed In employment other than IT Below university or undergraduate level student Postgraduate student PhD student Retired/Not working Other, please specify
7. Which languages do you use frequently? (please indicate all that apply)
- Java C++ C# Ajax Perl Other, please specify

B) Participation / contribution to the OSS Community

1. How often do you communicate with other members in the OSS Community?
- Every day Nearly every day Once / twice in a week Once / twice in a month Other, please specify
2. On average how many hours per week do you contribute to the OSS Community?
3. What percentage of your participation is related with project development in the OSS Community? %

C) Motivations & benefits of contributing to the OSS Community

Rating as appropriate from 5 - "strongly agree" to 1 - "strongly disagree".

1. What are your personal motivations to contribute to the OSS Community?

Hobby

- a) I enjoy writing programs. 5 4 3 2 1
- b) Programming gives me a chance to do what I can do the best. 5 4 3 2 1
- c) I spend my free time with programming. 5 4 3 2 1
- d) Programming is my favourite activity. 5 4 3 2 1
- e) I cannot imagine my life without programming. 5 4 3 2 1

Psychological factors

- f) I enjoy helping other people. 5 4 3 2 1
- g) I have altruistic approach in communication with other people. 5 4 3 2 1
- h) It gives me the feeling of success. 5 4 3 2 1

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3 i) It gives me the feeling of competence. 5 4 3 2 1

4 j) It gives me the feeling of effectiveness. 5 4 3 2 1

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7 Philosophical factors

8 k) I believe software should be free. 5 4 3 2 1

9 l) OSS is more secure than commercialised software. 5 4 3 2 1

10 m) OSS is more updated than commercialised software. 5 4 3 2 1

11 n) I contribute to the OSS Community because of reciprocal approach. 5 4 3 2 1

12 o) I want to be one who creates free software available for using by everybody. 5 4 3 2

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17 1

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19 2. What are your professional motivations to contribute to the OSS Community?

20 Main work needs

21 a) The software itself is my main job. 5 4 3 2 1

22 b) The software is critical for my main job. 5 4 3 2 1

23 c) I prefer individualistic approach in my work. 5 4 3 2 1

24 d) Increases my social prestige (social competence and skills). 5 4 3 2 1

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29 Personal needs

30 e) I use OSS myself (excluding programming or testing activities). 5 4 3 2 1

31 f) The software provides functionality that matches my unique and specific needs.

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33 5 4 3 2 1

34 g) Improves the level of my programming skills. 5 4 3 2 1

35 h) Gives me extra opportunities for learning. 5 4 3 2 1

36 i) I like sharing my knowledge and skills. 5 4 3 2 1

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40 Network opportunities

41 j) To exchange advice and solutions with knowledgeable people. 5 4 3 2 1

42 k) To keep abreast of new ideas and innovations. 5 4 3 2 1

43 l) To be one of the team who produce the innovative software. 5 4 3 2 1

44 m) To be meet new and different people. 5 4 3 2 1

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49 3. What are the long-term benefits of contributing to the OSS Community for you?

50 a) After participating the OSS Community, I can improve career progression prospects.

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52 5 4 3 2 1

53 b) After participating the OSS Community, I can increase my income in my main work place.

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55 5 4 3 2 1

56 c) After participating the OSS Community, I can increase my income from additional activities by using OSS.

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58 5 4 3 2 1

d) I will establish my own business by selling consulting, training, implementation or customisation services related to the project. 5 4 3 2 1

D) Management in the OSS Community

1. When you add new code, who accepts it?

Peer review Project Administrator Other, please specify

2. Is there a clearly identifiable person who coordinates your OSS Community?

No Yes, please specify N/A

3. With whom from the following hierarchical staff have you had contacts in your OSS project/s? (please indicate all that apply)

Forum/Project moderators Your peers Company/Product/Service top management team
 Other, please specify

4. Are you satisfied with the management of your OSS Community?

Very Satisfied Satisfied Neither Satisfied nor Dissatisfied Dissatisfied Very Dissatisfied

Questions 5-9 - Rating as appropriate from 5 - "strongly agree" to 1 - "strongly disagree".

5. I receive on time the information needed to do my job in the OSS Community.

5 4 3 2 1

6. The Project Administrator offers guidance for solving job-related problems.

5 4 3 2 1

7. I am satisfied with the supervision in the OSS Community. 5 4 3 2 1

8. I am satisfied with organisational commitment in the OSS Community. 5 4 3 2 1

9. I am satisfied with my co-workers in the OSS Community. 5 4 3 2 1

10. Do you gain any monetary rewards for your contribution to the OSS Community? Yes No

11. Who appointed you to your position in the OSS Community?

Peer review Project Administrator Other, please specify

12. Are you a formal employee or a volunteer contributor in the OSS Community?

A formal employee A volunteer Other, please specify

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Table 1 Motivations to share knowledge in OSS Communities

Category	Motivation	Literature
Hobbies	Intrinsic motivations, enjoyment of the work itself	Prasarnphanich & Wagner, 2011; Mikkonen, Vaden & Vainio, 2007; Hertel, Niedner & Herrmann, 2003; Lakhani & von Hippel, 2002
Philosophical Factors	“Fight” against proprietary software	Prasarnphanich & Wagner, 2011; Chang & Chuang, 2011; Baytiyeh & Pfaffman, 2010; Rullani, 2006; Ulhoi, 2004; Bonaccorsi & Rossi, 2003
Accomplishment	Feeling of solidarity, feeling of efficiency, reputation	Baytiyeh & Pfaffman, 2010; Mikkonen, Vaden & Vainio, 2007; Schroer & Hertel, 2007; Rullani, 2006; Ulhoi, 2004; Bonaccorsi & Rossi, 2003
Altruism	Self-determination, Altruism	Prasarnphanich & Wagner, 2011; Chang & Chuang, 2011; Baytiyeh & Pfaffman, 2010; Sowe, Stamelos and Angelis, 2008; Rullani, 2006; Ulhoi, 2004; Hertel, Niedner & Herrmann, 2003; Bonaccorsi & Rossi, 2003; Hars & Ou, 2002; Lakhani & von Hippel, 2002
Network Opportunities	Learning, Social interaction / prestige, Reciprocation, Peer’s respect and recognition, Community identification	Sowe, Stamelos and Angelis, 2008; Schroer & Hertel, 2007; Rullani, 2006; Ulhoi, 2004; Hertel, Niedner & Herrmann, 2003; Bonaccorsi & Rossi, 2003; Hars & Ou, 2002; Lakhani & von Hippel, 2002; Faraj & Wasko, 2001
Personal Needs	Community identification, Personal challenges to improve existing software for own needs	Prasarnphanich & Wagner, 2011; Chang & Chuang, 2011; Sowe, Stamelos and Angelis, 2008; Rullani, 2006; Ulhoi, 2004; Hertel, Niedner & Herrmann, 2003; Bonaccorsi & Rossi, 2003; Hars & Ou, 2002; Lakhani & von Hippel, 2002
Main Work Needs	Needs in the main work, Part of the main work, The software is critical for the main work, Information gathering, Developing knowledge for the main work	Mikkonen, Vaden & Vainio, 2007; Rullani, 2006; Ulhoi, 2004; Bonaccorsi & Rossi, 2003; Lakhani & von Hippel, 2002

Table 2: Measurements of the variables / factor analysis

Variables	Measurements <i>(Derived from the questionnaire see Appendix 1)</i>	Cronbach's Alpha Reliability Statistics	Rotated Component Matrix
Dependent Variable – Motivations	<ol style="list-style-type: none"> 1. Hobbies 2. Philosophical factors 3. Accomplishment 4. Altruism 5. Network opportunities 6. Personal needs 7. Main work needs 	<ol style="list-style-type: none"> 1. .865 2. .721 3. .878 4. .782 5. .823 6. .735 7. .781 	>0.5
Moderating Variable – Management	<ol style="list-style-type: none"> 1. Satisfaction with the management of an OSS Community 2. Receiving the needed information on time 3. Guidance from the project administrator 4. Satisfaction with supervision 5. Satisfaction with organisational commitment 6. Satisfaction with co-workers 	.862	>0.5
Independent Variable – Knowledge Sharing	<ol style="list-style-type: none"> 1. Individuals' frequency of communication with members of the community (FREQ COM) 2. Hours per week knowledge shared in the OSS project (HOURS PER WK) 3. A percentage of the participation related to project development in the OSS community (% PART PROJ DEV) 	.818	>0.5

Peer Review

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Table 3 Correlations analysis

Variables		Analysis	1	2	3	4	5	6	7	SatMngt	KnSh
MOTIVATIONS	1) Hobby	Pearson Correlation	1								
		Sig. (2-tailed)									
	2) Philosophical Factors	Pearson Correlation	.111	1							
		Sig. (2-tailed)	.230								
	3) Accomplishment	Pearson Correlation	.218*	.295**	1						
		Sig. (2-tailed)	.016	.001							
	4) Altruism	Pearson Correlation	.159	.380**	.758**	1					
		Sig. (2-tailed)	.083	.000	.000						
	5) Network Opportunities	Pearson Correlation	.247**	.342**	.351**	.269**	1				
		Sig. (2-tailed)	.007	.000	.000	.003					
	6) Personal Needs	Pearson Correlation	.124	.623**	.504**	.555**	.532**	1			
		Sig. (2-tailed)	.177	.000	.000	.000	.000				
	7) Main Work Needs	Pearson Correlation	.024	.219*	.067	.108	.253**	.219*	1		
		Sig. (2-tailed)	.794	.014	.453	.229	.005	.014			
SATISFACTION WITH MANAGEMENT (SatMngt)		Pearson Correlation	.119	.305**	.262**	.367**	.310**	.393**	.175	1	
		Sig. (2-tailed)	.221	.001	.005	.000	.001	.000	.066		
KNOWLEDGE SHARING (KnSh)		Pearson Correlation	.083	.198*	.217*	.254**	.196*	.304**	.110	.213*	1
		Sig. (2-tailed)	.370	.029	.015	.005	.032	.001	.223	.027	
*. Correlation is significant at the 0.05 level (2-tailed).											
**. Correlation is significant at the 0.01 level (2-tailed).											

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Table 4 Multiple regression analysis

a) Summary

Dependent variable		Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
MOTIVATIONS	Hobby	1	.185 ^a	.034	-.005	.97195
		2	.200 ^b	.040	-.009	.97391
	Philosophical Factors	1	.278 ^a	.077	.040	.79469
		2	.399 ^b	.159	.117	.76229
	Accomplishment	1	.259 ^a	.067	.030	.88523
		2	.353 ^b	.124	.080	.86204
	Altruism	1	.311 ^a	.097	.060	.78328
		2	.448 ^b	.201	.160	.74067
	Network Opportunities	1	.237 ^a	.056	.018	.71908
		2	.378 ^b	.143	.099	.68863
	Personal Needs	1	.418 ^a	.175	.141	.64707
		2	.553 ^b	.306	.270	.59655
	Main Work Needs	1	.143 ^a	.020	-.019	1.32547
		2	.212 ^b	.045	-.004	1.31552
a. Predictors: (Constant), KNOWLEDGE SHARING						
b. Predictors: (Constant), KNOWLEDGE SHARING, SATISFACTION WITH MANAGEMENT						

Peer Review

b) Anova

Dependent variable		Model	Sum of Squares	df	Mean Square	F	Sig.	
MOTIVATION S	Hobby	1	Regression	3.312	4	.828	.876	.481 ^b
			Residual	93.524	99	.945		
			Total	96.836	103			
		2	Regression	3.883	5	.777	.819	.539 ^c
			Residual	92.953	98	.948		
			Total	96.836	103			
	Philosophical Factors	1	Regression	5.232	4	1.308	2.071	.090 ^b
			Residual	62.521	99	.632		
			Total	67.753	103			
		2	Regression	10.806	5	2.161	3.719	.004 ^c
			Residual	56.947	98	.581		
			Total	67.753	103			
	Accomplishment	1	Regression	5.595	4	1.399	1.785	.138 ^b
			Residual	77.579	99	.784		
			Total	83.174	103			
		2	Regression	10.348	5	2.070	2.785	.021 ^c
			Residual	72.825	98	.743		
			Total	83.174	103			
	Altruism	1	Regression	6.516	4	1.629	2.655	.037 ^b
			Residual	60.739	99	.614		
			Total	67.256	103			
		2	Regression	13.494	5	2.699	4.919	.000 ^c
			Residual	53.762	98	.549		
			Total	67.256	103			
Network Opportunities	1	Regression	3.033	4	.758	1.466	.218 ^b	
		Residual	51.191	99	.517			
		Total	54.224	103				
	2	Regression	7.752	5	1.550	3.269	.009 ^c	
		Residual	46.473	98	.474			
		Total	54.224	103				
Personal Needs	1	Regression	8.782	4	2.196	5.244	.001 ^b	
		Residual	41.451	99	.419			
		Total	50.233	103				
	2	Regression	15.358	5	3.072	8.631	.000 ^c	
		Residual	34.875	98	.356			
		Total	50.233	103				
Main Work Needs	1	Regression	3.629	4	.907	.516	.724 ^b	
		Residual	173.931	99	1.757			
		Total	177.559	103				
	2	Regression	7.961	5	1.592	.920	.471 ^c	
		Residual	169.599	98	1.731			
		Total	177.559	103				

b. Predictors: (Constant), KNOWLEDGE SHARING
c. Predictors: (Constant), KNOWLEDGE SHARING, SATISFACTION WITH MANAGEMENT

c) Coefficients

Coefficients		MOTIVATIONS																				
		Hobby			Philosophical Factors			Accomplishment			Altruism			Network Opportunities			Personal Needs			Main Work Needs		
Model		Stand.Coeff. Beta	t	Sig.	Stand.Coeff. Beta	t	Sig.	Stand.Coeff. Beta	t	Sig.	Stand.Coeff. Beta	t	Sig.	Stand.Coeff. Beta	t	Sig.	Stand.Coeff. Beta	t	Sig.	Stand.Coeff. Beta	t	Sig.
1	(Constant)		6.126	.000		6.329	.000		5.501	.000		6.039	.000		7.492	.000		8.428	.000		3.447	.001
	KNOWLEDGE SHARING	.041	.372	.711	.280	2.631	.010	.255	2.379	.019	.316	2.993	.003	.208	1.927	.057	.412	4.084	.000	.110	1.002	.319
2	(Constant)		4.336	.000		3.286	.001		2.889	.005		2.830	.006		4.216	.000		4.549	.000		1.759	.082
	KNOWLEDGE SHARING	.028	.252	.801	.233	2.255	.026	.215	2.042	.044	.262	2.603	.011	.159	1.524	.131	.352	3.746	.000	.084	.764	.447
	SATISFACTION WITH MANAGEMENT	.081	.776	.440	.301	3.097	.003	.251	2.529	.013	.339	3.566	.001	.310	3.154	.002	.380	4.298	.000	.164	1.582	.117

Significance level: p < .05*; p < .01**; p < .001***