

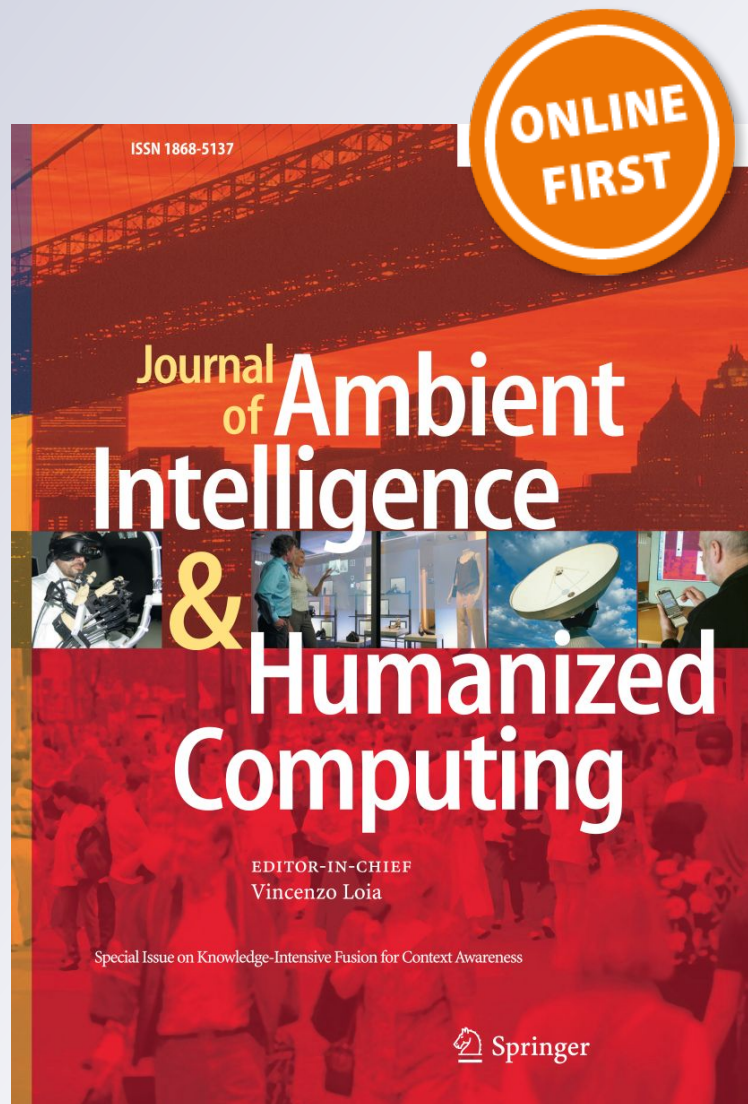
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User acceptance model of open source software: an integrated model of OSS characteristics and UTAUT

Thamer A. Alrawashdeh¹ · Mohammad W. Elbes² · Ammar Almomani³ · Fuad ElQirem⁴ · Abdelfatah Tamimi¹

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Abstract

Globally, the acceptance of Open Source Software (OSS) varies among the users of a company. Despite the substantive software, social, and infrastructure-related implications of OSS acceptance, the research on the acceptance of OSS across organizations inhabitants remains surprisingly limited. To propose a model for the acceptance of OSS; investigate the influence of the OSS characteristics, UTAUT constructs, and infrastructure factors on the acceptance of open source software system. It also examines the validity of UTAUT in the open source software context. Quantitative design has been used following the distribution of questionnaire among a sample of 255 individuals employed at public and private organizations (172 males and 83 females). Software quality, software interoperability, and software security had a significant impact on the performance expectancy (PE) ($\beta=0.445$, $P<0.001$), ($\beta=0.302$, $P<0.001$), ($\beta=0.139$, $P<0.05$), respectively. Moreover, PE, cost, facilitating conditions, social influence SI and self-efficacy had a notable impact on the behavioral intention ($\beta=0.275$, $P<0.05$), ($\beta=0.229$, $P<0.01$), ($\beta=0.136$, $P<0.01$), ($\beta=0.220$, $P<0.01$) and ($\beta=0.174$, $P<0.01$) respectively. A new path appears to exist between EE (effort expectancy) and PE ($\beta=0.215$, $P<0.01$). The outcomes indicated that users perceive that OSS user-friendliness must be upgraded for optimizing its benefits. It showed that performance expectancy, effort expectancy, social influence, self-efficacy, software security, software quality, software interoperability, and software cost are important indicators in the acceptance and implementation of OSS. Further research can be conducted in organizations to observe the implementation of OSS and its effectiveness.

Keywords Acceptance of OSS · Adaption of OSS · UTAUT · Acceptance testing · OSS characteristics

1 Introduction

Globally, Open Source Software (OSS) is substantially recognized in the corporate environment. Interestingly, it offers various benefits to organizations and individuals as it provides access to various free and robust applications (Van Loon and Toshkov 2015; Jan 2018). Scholars defined OSS as computer software developed in a public collaborative

manner, and distributed under a license which guarantees the users rights to access, modify, reuse, and redistribute the source code freely (Fontana 2010). Thus, the central idea of the software relies on the freedom to read, modify, reuse, and redistribute the source code, despite the cost.

Organizations and individuals use several ways to adapt OSS, which comprise deploying OSS in their environment as the end-user; integrating OSS components with their systems; using computer-aided software engineering to develop OSS; working with OSS communities to develop OSS software; and participating in OSS development controlled by other organization (Hauge et al. 2010).

The implementation and acceptance of the OSS have faced several challenges regarding the several software characteristics entailing software complexity, software quality, security, and the ability of the developed open source software to exchange data with other software (software interoperability) (Safadi et al. 2015). Kantor et al. (2003) highlighted the unique characteristics of OSS in resolving

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obstacles associated with the acceptance and the implementation of open source software, comprised of improved customization, and low cost of acquisition and maintenance. Feller and Fitzgerald (2002) added that software characteristics are integral as it allows the acceptance of software. Thereby, the research on the effects of open source software's characteristics on software acceptance is deemed as a meaningful research contribution. The research is further advanced based on the fact that previous research attempts have been concentrated on the motivation against the implementation of open source software, and organizations adoption of such software. Moreover, Qu et al. (2011) divided the motivation factors for the implementation of OSS into three groups; technological, economic, and sociopolitical. Similarly, Safadi et al. (2015) have discussed the OSS potential to overcome IT adoption challenges concerning the electronic medical record system. The findings suggested that the dynamics of OSS development can improve technology adoption in the healthcare sector. In the same year, Cheng et al. (2015) modified TAM to develop a robust model for examining the acceptance of E-profile system. The main contribution behind Chengs' work was that gender moderates the impact of other motivation factors on the acceptance of E-profile system.

The review of the literature highlights the gap concerning the impact of the OSS characteristics on software acceptance. Also, these provide limited information on how the software acceptance differs among various groups concerning the open source software, mainly in IT specialist and IT generalist group. Such as, many scholars have stated that demographic variables impact the acceptance of a software (Lai and Li 2005; Shroff et al. 2011; Li and Kirkup 2007; Esposito et al. 2019). Therefore, the present study identified software interoperability, software security, software complexity, and software quality as key components of open source software, and examines their impact on the intention and the actual use of the users. Furthermore, the study attempts to use IT specialty as a moderator to profoundly understand the acceptance of open source software and related issues. More importantly, it integrates such software characteristics with the unified theory of acceptance and use of technology (UTAUT). It develops a research framework to examine the acceptance of open source software by confirming the convergent, discriminant, and internal validity of UTAUT and proposes a model via structural equation modeling (SEM).

This study also identified not only the acceptance behavior but also the actual usage of OSS as emphasized by existing researches which direct attention to measurement of the cost and interoperability of OSS based on its impact on the usage intention of OSS. Finally, an empirical study is introduced using datasets from multiple groups to answer the research questions.

Overall, the remainder of this paper is categorized into seven sections as follows: section two presents a brief background to OSS characteristics and UTAUT and a literature overview concerning the OSS acceptance. The third section proposes and comprehensively discusses the research model and hypotheses, while section four enlightens the research method. In section five, the data analysis and results are reported. The research results and implications are discussed in section six. Finally, section seven concludes this paper and presents results, implications, limitations, and the direction for the future works in the same line of research.

2 Background and literature review

2.1 OSS characteristics and challenges

As previously mentioned, studies have emphasized the evaluating, weighing, and determining the challenges and characteristics of open source software for successfully developing OSS. This evaluation would also enable the successful and practical implementation of an open source software product success. Such challenges and characteristics are explained below:

2.1.1 Software Interoperability

Open source software's interoperability reveals software ability to openly exchange information with other open source software products or proprietary software products any restricted access or implementation (Almeida et al. 2011). This interoperability is reflected as the main challenge encountered by the most open source software vendors and organizations. However, it is established that open source methodology relies on the collective working of the individual groups or companies at the level of code to develop high-quality software products with low cost (Aberdour 2007). This methodology has proven to be beneficial for different types of businesses given its optimization of the software interoperability. These software products could easily connect each other beyond methodology. Additionally, the availability of source code provides the IT specialists opportunities to extensively study the code in detail and make relevant changes either individually or through collective efforts to overcome this challenge.

Lewis (2013) study revealed that, generally, open standards enable the software interoperability. Where open standards are defined as a formal description of software or software interfaces. In the open source software context, the implementation of open standards enables software interoperability through the establishment of clear rules for exchanging data. Various software projects have developed standards for open source software systems and

their interoperability; namely: ArgoUML by Jason Robbins, AndroMDA by Matthias Bohlen, MICO by Arno Puder, and Open Document Format (ODF) by ISO (Siegel and Soley 2008).

2.1.2 Cost

Cost is reflected as a critical factor to implement open source software. According to Walli et al. (2007), implementation of open source software has allowed organizations and individuals to reduce their expenditure on IT functions. Therefore, the use of open source software increases in case it is free or with low price. However, the effective implementation requires the organizations and individual to develop the necessary competence to maintain, enhance, customize, and support the system needs. Thus, it must be recognized that the cost of OSS implementation integrates not only the license cost, but also the cost of customization, maintenance, and support. Consequently, if the inhouse competence lacks the information on software customization and maintenance, then adoption of such software should not be risked. Moreover, if the firm core deviates from software development, then commercial software may better suit the firm needs. For this end, it's worth investigating the influence of open source cost on the acceptance of such software.

2.1.3 Security

Although it is expressed as the most important open source software characteristics, it also increases the risk for malware attacks can identify vulnerabilities in the open source software using the system codes. Aspect Security report in 2012 stated that open source software security vulnerability exceeds its expectations, which vary among the organizations (Williams and Dabirsiaghi 2012). Despite its vulnerability, the software is being employed in most of the global organizations (West and Gallagher 2006). This aspect might refer to the ability of the IT specialists in such organizations who are able to modify the code of open source software. Given the security concerns, most organizations and individuals are sceptical concerning the implementation of the open source software leading to its rejection.

2.1.4 Complexity

Complexity is an essential characteristic which determines the success or failure of the software implementation (Alenezi and Almustafa 2015; Manzoor et al. 2019). While advanced researches have studied software complexity for proprietary software; the findings appear to be ambiguous for the open source software (Barry et al. 2007). Concerning this, the open source software should offer ease of use for improving the acceptance ratio among the users.

2.1.5 Software quality

Open source software methodology offers various open source software applications with varying quality. The availability of these applications' source code and published process-related artifacts including configurations management system logs, mailing lists, and bugs files, have provided the quality observatories with data that are necessary to evaluate the open source software quality (Spinellis 2006). This aspect leads individuals and organizations to implement only open source software products that are characterized by good quality.

2.2 Prior studies

The acceptance of software systems is one of the widely studied topics in the literature. Several studies have attempted to analyze the acceptance of software systems from different perspectives (Cheng et al. 2015; Baptista and Oliveira 2015; Cheng 2015; Park and Del Pobil 2013; Haider et al. 2019; López-Jaquero et al. 2019). All of these studies defined the factors that impact the acceptance of software systems. These factors mainly include satisfaction, quality, security, hedonic motivations (system enjoyment), performance, usability (complexity), culture, and social identification.

Interestingly, García et al. (2019) employed the UTAUT to propose an evaluation process for a tool that developed to enhance affect recognition in patients with social cognition deficits. Whereas, quantitative research in the form of the questionnaire-based survey was conducted to examine the influence of performance expectancy, effort expectancy, facilitating condition, social influence, and hedonic motivation on the therapists' behavioral intention to use the developed tool. The results of this study show that 75% of the participants have the intention to use the developed tool once it implemented.

Focusing on the open source software, very few studies have investigated the acceptance and adoption of such software by organizations and individuals. For instance, Gwebu and Wang (2011) proposed a model using the Technology Acceptance Model (TAM) to investigate the impact of social identification and personal innovativeness on the user intention to use open source software. Based on the survey of 280 professional workers, the study suggested that perceived usefulness has an insignificant impact on open source software usage as compared to the perceived ease of use. This indicates that open source software is difficult to learn and understood. Moreover, the same study found a significant relationship between personal innovativeness and open source software while no relationship between personal innovativeness and perceiving usefulness. Finally, social identification influenced open source software usage as well as the perceiving usefulness and perceived ease of use.

Miller and Collins (2001) presented open source software as a potential solution for the challenges that surrounded the adoption of health information technology in North America, using a Canadian open source electronic medical record system as a case study. It showed that the development methodology of open source software provides a potential solution for low adoption software in healthcare. Moreover, other studies have been conducted to investigate the adoption of open source software (Qu et al. 2011; Cheng et al. 2015). Furthermore, the concern of the prior studies is on the factors that are related to the organization's management, process, and social influence, but not on the software characteristics. While the acceptance among the users was tested to assure consistency between the developed software system and the business (Miller and Collins 2001). Thus, the present study intends to measure the acceptance of any software by measuring the software characteristics.

The significant relationships between the independent variables and the intention to use information systems might be affected by different demographic variables (Cheng et al. 2015; Shroff et al. 2011). However, it is clear from the literature that there is no research conducted to measure the variance across different groups in order to understand whether the usage intention of IT specialists differs from the specialist from other areas (Wurster et al. 2011).

2.3 Unified theory of acceptance and use of technology (UAUT)

Numerous research studies have attempted to define and determine the factors that affect the acceptance of software's innovations among organizations' employees and individuals. These studies are based on theories such as Theory of reasoned action (TRA) by Ajzen and Fishbein (1980), Technology Acceptance Model (TAM) by Davis et al. (1992); Theory of Planned Behavior (TPB) by Ajzen (1991); and Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003).

The modern theory among these is UTAUT (Ong et al. 2004). It was developed based on the constructs of eight prominent theories that were previously used to explain the acceptance of computer information systems. These comprised of theory of reasoned action (TRA), technology acceptance model (TAM), theory of planned behavior (TPB), motivational model (MM), an integrated model of TAM and TPB innovation diffusion theory, model of PC utilization (MPCU), and social cognitive theory (SCT). This consideration named four constructs for UTAUT: performance expectancy, effort expectancy, social influence, and facilitating conditions, grouping similar earlier constructs. The new theory considers a set of moderators that could affect the relationships between its constructs. These moderators are age, gender, experience, and voluntariness

(Venkatesh et al. 2003). Although, UTAUT has compelled the interest of scholars and has been employed to measure the acceptance and use of information technology for individuals and organization in many contexts, its application and examination in the OSS context remains unexplored. Therefore, this study adopts the UTAUT to examine the acceptance of the OSS software.

3 User acceptance model of open source software

The main novelty of this research work is to propose an acceptance model for open source software by considering the open source software characteristics and the IT specialty as a moderator variable between those characteristics and OSS acceptance. For this purpose, UTAUT's constructs have been combined with characteristics of open source software and IT specialty as moderator (Fig. 1). The conceptual framework integrated nine factors that could affect the OSS acceptance, namely: performance expectancy, effort expectancy, social influence, self-efficacy, facilitating conditions, software interoperability, cost, software security, and software quality.

3.1 Performance expectancy (PE)

Performance expectancy refers to the degree to which users believe that using software system would be useful for performing their tasks (Venkatesh et al. 2003). According to Compeau and Higgins (1995), people accept and use

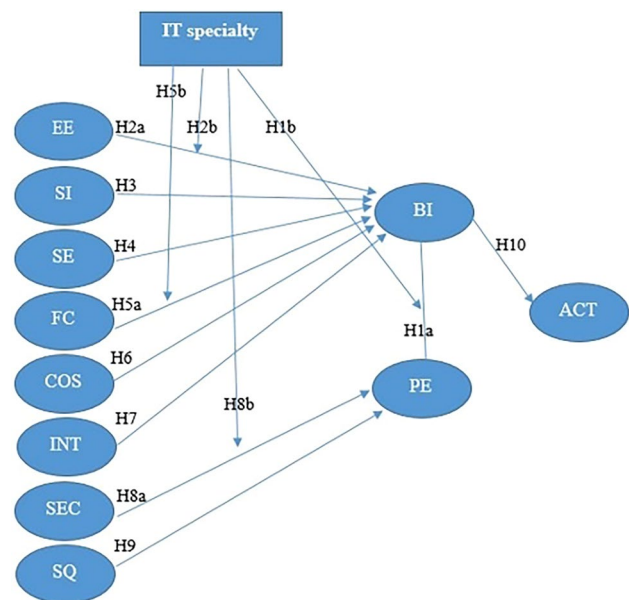


Fig. 1 Proposed research model

computing systems only if they believe that it enhances their outcomes. Reflecting the perception of enhancement by using open source software measures is helpful for improved and customizable software. Particularly for individuals that possess effective software development skills and knowledge on common integrated development environment (IDE) or computer-aided software engineering (CASE) (IT specialists). It could be anticipated that performance expectancy is a strong factor for accepting open source software. Thus, two hypotheses have been formulated:

H1a The performance expectancy has a positive impact on the intention to use open source software.

H1b IT specialty moderates the relationship between performance expectancy (PE) and behavioral intention (BI), in such a way that the relationship will be stronger among the individuals with IT specialty.

3.2 Effort expectancy (EE)

Effort Expectancy is the degree to which an individual believes that the use of a software system would be easy and effortless (Venkatesh et al. 2003). Additionally, the availability of source code in regards to OSS, especially for IT specialty makes it possible to redesign the user interface. Therefore, two more hypotheses have been formulated:

H2a The EE has a positive impact on the intention to use open source software.

H2b IT specialty moderates the relationship between EE and behavioral intention (BI), in such a way that the relationship will be stronger among the individuals with IT specialty.

3.3 Social influence (SI)

Social Influence refers to the individuals' perception of the opinion of other people, especially friends and colleagues (Venkatesh et al. 2003). For this variable, the following hypothesis is formulated:

H3 The social Influence has a positive impact on the intention to use the OSS.

3.4 Computer self-efficacy (SE)

Computer self-efficacy refers to which the users believe that they are competent to perform a particular task using particular computer software (Compeau and Higgins 1995). Based on the concept of open source software, self-efficacy is related to users' judgmental analysis of using open source

software. The relationship between SE and behavioral intention was empirically-supported, which was based on the casual interlinks (Ong et al. 2004). This aspect suggested that the acceptance of open source software is based on the individual's capabilities to use it.

H4 The computer self-efficacy has a positive impact on the behavioral intention to use the open source.

3.5 Facilitating conditions (FC)

Facilitating condition is the extent to which individuals perceive that available resources and support are required to use software systems (Van der Heijden 2004). Using open source software demands the recognition of Linux-based operating systems' commands lines such as access to the repositories and installation of the applications. Similarly, users need to access the source code to reach a detailed understanding of how the system works (Cheng et al. 2015). Thus, the peoples' ability to have access on a valuable set of the facilitating conditions including open source software online tutorial, developers' forums is also valuable.

H5a The effect of facilitating conditions on the intention to use the open source software will be positive.

H5b IT specialty moderates the relationship between facilitating conditions (FC) and behavioral intention (BI), in such a way that the relationship will be stronger among the individuals with IT specialty.

3.6 Cost (COS)

Cost is the comparison between the perceived benefits of using software systems and the monetary cost that is associated with its usage (Venkatesh et al. 2003; Moreira et al. 2019). It also includes software installation and supplying services. It could be anticipated that the cost may have a significant effect on the acceptance and usage of software systems, as evident from the use of mobile applications where short message services are mainly used based on their low price (Venkatesh et al. 2003; Chan et al. 2008; Moreira et al. 2019). In the open source software context, the IT function cost decline by implementing open source software (Walli et al. 2007). Therefore, organizations and individuals could implement and use open source software if obtained for free or at a low price. Thus, the cost is added as a predictor of intention to use open source software.

H6 The cost has a positive impact on the intention to use open source software.

3.7 Interoperability (INT)

Many software companies can produce both small and large software. However, the best software is identified based on its compatibility with individual needs. Interoperability refers to the ability of software to exchange information with other software, which itself is a standard in the software industry (Almeida et al. 2011). It is well-known that the open source methodology relies on the collective working of groups or companies, at the level of code to develop a high-quality software product with low cost (Aberdour 2007). In the acceptance context, no study has been conducted to evaluate the relationship between the interoperability and the acceptance of software products. Therefore, this study proposed some measures to investigate the relationship between open source software interoperability and behavioral intention to use such software.

H7 The software interoperability has a positive impact on the behavioral intention to use open source software.

3.8 Security (SEC)

Perceived security can be defined as the degree to which individuals and organizations believe in software security (Shin 2010). As previously mentioned, the OSS's source code makes it more vulnerable to software hackers and malware. Despite it, its use among the firms remains high based on the IT specialist ability to modify the code of open source software. Many studies have investigated the influence of perceived security on the acceptance of software systems (Shin 2010; Yenisey et al. 2005). Such studies found that perceived security have a critical impact on the perceived usefulness and similar effect on the acceptance and utilization of the information systems.

H8a Software security will have a positive impact on the PE of OSS.

H8b IT specialty moderates the relationship between software security (SEC) and behavioral intention.

3.9 Software quality (SQ)

The software products are realized by the quality of its services, which mainly include time, reliability, and privacy concerns (Seddon 1997; Letswamotse et al. 2019). Many scholars indicated that software quality is one of the common variables that influence the acceptance of software systems. Since, the end-users generally accept and use software that resulted in high performance (Venkatesh et al. 2003; DeLone and McLean 1992; Manzoor et al.

2019). Certain studies revealed that the defined variables of software quality significantly affect the users' acceptance (Park and Del Pobil 2013; Park and Kim 2014). However, the relationship between the OSS's quality and user intention is unexplored; thus, the following hypothesis has been proposed:

H9 There is a significant relationship between OSS's quality and the user's intention to use OSS.

3.10 Intention to use (BI)

According to the underlying theories of acceptance software systems, the behavioral intention is about the willingness of users to perform a given behavior (Venkatesh et al. 2003). Similarly, it is considered to be a good indicator of the actual use of software systems (Šumak et al. 2011; Zhang et al. 2008). Thus, this study has also proposed the following hypothesis:

H10 There is a significant relationship between a user's behavioral intention and their actual use (ACT) of OSS.

Figure 1 shows the research model and the developed hypotheses. In order to evaluate the research hypothesis, the proposed model has been examined comprehensively.

4 Research method

A quantitative method is used for providing accurate and reliable results, statistically. The literature presents various types of quantitative methods, namely: field experiments, surveys, simulation, and correlational studies. Among these, surveys are the most commonly deployed research methods. It allows collecting data about a given phenomenon through a set of questions that reflect the opinions, perceptions, and behaviors of individuals towards it (Queirós et al. 2017; Walker 2005). This type of quantitative research provides many benefits over others, including the high representativeness of population, the low cost of data collection, and no affected of researchers' subjectivity (Queirós et al. 2017).

Given this, this research was conducted through the analytical aspects of quantitative design using the survey technique. The population of the study comprised of OSS users that use it for their learning, at their work, or for other purposes. In order to ensure the IT specialty as a moderator variable, the participants were 255 OSS users (172 males and 83 females) with different specialties including information technology specialists and information technology generalists (engineering, business, pharmacy, act). A

questionnaire was developed and distributed among OSS users during April and September 2017.

The instrument items have been adapted, from previously validated studies for examining the perception of participants on the proposed model constructs (“Appendix”). Regarding the measures of interoperability construct, it has been developed based on the definitions of the concept as provided in the literature (Gortney 2016; Wilson 1994; Ibrahim and Adamu 2018).

Before conducting the main survey, a pilot test had been conducted to validate the questionnaire. Twenty OSS users were instructed to answer the questionnaire and notify for any misleading and unclear items. Additionally, three academicians were asked to review and reword the questionnaire items. The main inconvenience identified in the pilot test was the different orientation of the questionnaires’ questions, existing both negative and positive ones. This variation could make the data analysis process complicated. Thus, all questionnaires questions had been rewritten in a positive sense, and two ambiguous questions were modified. The feedback and comments from the respondents signified to create the final draft of the questionnaire. Consequently, Cronbach’s alpha test was applied to evaluate the reliability of scales. This test confirmed that the Cronbach’s alpha values for all questionnaire’s items was above the recommended value of 0.7 (PE = 0.87, EE = 0.87, SQ = 0.91, SI = 80, FC = 0.92, SE = 0.94, COS = 0.86, SEC = 0.98, INT = 0.74, BI = 0.82) (George and Mallery 2003) (“Appendix”).

The researchers administrated the survey to obtain a high response rate. They visited more than 30 public and private organizations from different areas, including educational, industrial, and service areas. 3 of these organizations have up to 50 inhabitants (small-sized organizations), 10 organizations have up to 250 inhabitants (medium-sized organizations), and 17 organizations have greater than 250 inhabitants (large-sized organizations) (Hillary 2004).

Consequently, the researchers asked employees, students, and software developers in these organizations to respond to the instruments’ items using a 7-point Likert scale. The rationale for the application of the 7-point Likert scale was to increase the measures variance and its enhanced reliability and just use for over 5- point Likert scale (Preston and Colman 2000). The participants belong to different specialties and are literature on the use of OSS, Linux operating system, web browsers act. From 300 questionnaires had been distributed, 261 questionnaires successfully returned to the researchers with the response rate of 87%. After data filtering, only 255 valid questionnaires had been analyzed through SPSS as 6 were discarded for data analysis due to incomplete data.

The AMOS tool had been applied later to analyze the collected data. The results of internal reliability and convergent validity tests revealed that all values of factor loadings and Average Variance Extracted (AVE) were higher (Hair et al. 2006). Additionally, the results supported the correlation between the two factors is less than the square root of the AVE. This aspect indicates good convergent and discriminant validations.

5 Results

5.1 Demographic characteristics of the respondents

The analysis of the OSS showed that majority of the sample was male, i.e., 172 (67%) and females were 83 (33%) age ranging between 18 and 60 years. The distribution of age (in years) was as follows: 18-20 (7%), 201-30 (60), 31-50 (29%) and greater than 50 (4%). The respondents who had completed his/her higher education in the Information Technology (IT) were (59%) and those who have other specialties (41%). The respondents have solid experience with internet usage. Regarding the open source software experience, the responses indicate that approximately half of the participants have experience with open source software usage. Table 1 represents the descriptive characteristics of usable respondents.

Table 1 Descriptive statistics of respondents’ characteristics

Demographic characteristics	Frequency	Percentage
Gender		
Male	172	67.45
Female	83	32.55
Age		
18–20	17	6.67
21–30	152	59.61
31–50	75	29.41
> 50	11	4.31
Specialty		
IT	105	41.17
Other specialization	150	58.83
Internet experience		
No experience	0	0
Some experience	31	12.16
Experienced	192	75.29
Very experienced	32	12.55
OSS experience		
No experience	131	51.37
Some experience	112	43.92
Experienced	10	3.92
Very experienced	2	0.79

5.2 Model Fit

The Confirmatory Factor Analysis (CFA) was conducted to evaluate how fit is the proposed model with the collected data. The following model-fit indices: Chi square/degree of freedom ($X^2/f.d$), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMSR), Normal Fit Index (NFI), Non-Normal Index (NNI), Comparative Fit Index (CFI), and Increment Fit Index (IFI). Table 2 shows that all previous model-fit indices were within the recommended thresholds. This aspect suggests that the research model fits the collected data appropriately.

In order to achieve the discriminant validity, the correlation shared between every two factors was less than the square root of AVE (Table 3).

5.3 Hypothesis tests

This study is amongst a few studies that investigated the acceptance of open source software. It involved not only the social and infrastructure factors in the proposed model

but also the software characteristics. Consequently, it is the first study to explain the relationship between software's cost and software's interoperability with the behavioral intention and actual use. Another contribution for this study is that it explains the difference between acceptance of OSS among users with information technology specialty and with other specialties.

As shown in Table 4 including the standardized path coefficient (β), t value, and P level (the relationships are significant when the t value > 1.96 and p > 0.05 (Cheng 2015)), which support that developed hypotheses as expected SQ, INT, and SEC had a significant impact on the PE ($\beta = 0.445$, $P < 0.001$), ($\beta = 0.302$, $P < 0.001$), ($\beta = 0.139$, $P < 0.05$) respectively. Moreover, PE, COS, FC, SI and SE had a notable impact on the BI ($\beta = 0.275$, $P < 0.05$), ($\beta = 0.229$, $P < 0.01$), ($\beta = 0.136$, $P < 0.01$), ($\beta = 0.220$, $P < 0.01$) and ($\beta = 0.174$, $P < 0.01$) respectively. A new path appeared to exist between EE and PE ($\beta = 0.215$, $P < 0.01$). This new relationship was consistent with the findings of prior studies (Davis et al. 1992; Gallego et al. 2008; Al-Gahtani 2016;

Table 2 Overall fits of model

Fit index	Research model	Recommended value	Source
$X^2/f.d$	1.078	< 5.00	Bollen and Stine (1992)
GFI	0.901	> 0.90	Arbuckle (1995)
AGFI	0.874	> 0.80	Browne and Cudeck (1993)
RMSEA	0.017	< 0.06	Jöreskog and Sörbom (1996)
NFI	0.961	> 0.90	Bentler and Bonett (1980)
NNI	0.990	> 0.90	Bentler and Bonett (1980)
CFI	0.997	> 0.90	Bullock et al. (1994)
IFI	0.997	> 0.90	Bullock et al. (1994)
SRMSR	0.028	< 0.08	Bagozzi and Yi (1988)

Table 4 Hypothesis testing results

Hypothesis	Standardized path coefficient (B)	P	Support
H1a: BI ← PE	0.275	0.013	Yes
H2a: BI ← EE	-0.017	0.824	No
H3: BI ← SI	0.220	0.003	Yes
H4: BI ← SE	0.174	0.010	Yes
H5a: BI ← FC	0.136	0.003	Yes
H6: BI ← COS	0.229	0.004	Yes
H7: PE ← INT	0.302	***	Yes
H8: PE ← SEC	0.139	0.018	Yes
H9: PE ← SQ	0.445	***	Yes
H10: ACU ← BI	0.659	***	Yes
New PE ← EE	0.215	0.002	Yes

*p < 0.05, t-value > 1.96, ** p < 0.01, t-value > 2.58, *** p < 0.001, t-value > 3.29

Table 3 The square root of AVE and factors correlation coefficients

	PE	EE	SI	SE	FC	SQ	SEC	COS	INT	BI
PE	1									
EE	0.89	1								
SI	0.88	0.87	1							
SE	0.90	0.86	0.88	1						
FC	0.82	0.77	0.83	0.77	1					
SQ	0.89	0.88	0.87	0.86	0.80	1				
SEC	0.87	0.86	0.85	0.87	0.76	0.88	1			
COS	0.89	0.87	0.86	0.89	0.81	0.89	0.86	1		
INT	0.89	0.86	0.88	0.89	0.84	0.88	0.86	0.85	1	
BI	0.74	0.88	0.91	0.88	0.85	0.86	0.88	0.87	0.89	1

Alsoub et al. 2018). Finally, behavioral intention and actual usage obtained a strong significant path coefficient with the value of 0.659. The proposed model demonstrated 0.95% of the variance in performance expectancy, 0.91% of the variance in behavioral intention to use open source software, and 0.56% of the variance in actual usage of open source software.

5.4 Result of moderating impact

The proposed model included hypotheses concerning the moderate impact of the IT specialty on other relationships, between the proposed model's factors. This impact was tested by comparing the path coefficient between two groups, namely: IT specialists and IT generalists. In order to test the impact of the moderating variables on the acceptance of OSS, two models had been measured based on these groups, which results were significant. Table 5 presented the results of path coefficients comparison.

The path coefficient for IT specialists from FC to BI was significantly larger than IT generalists. Furthermore, SEC and SI were more important factors for IT specialists as compared to IT generalists in providing PE and BI. It is worth mentioning that the path from COS to BI for IT specialists was significantly stronger than for IT generalists. However, the other relationships were not significantly affected by IT specialty.

6 Discussion

The study results provide several theoretical and practical implications for organizations, software developers, and academic researchers. It offers a comprehensive framework that integrates UTAUT and OSS characteristics based on the SEM. The significant results of the proposed model fit indices and confirmation of the relationships between the model's constructs are appropriate and provide evidence for the validity of the proposed user acceptance model. Fitzgerald (2006) investigated the transformation of OSS, in which framework product factors and the process was employed

to discuss the bazaar metaphor associated with the open source development process. It showed that OSS is opposite to independent antecedent software. Likewise, corroborating the present study findings, another research discussed that open source development depicted as a compound model for innovation, which consisted of components of private investment as well as collective models (Hippel and Krogh 2003).

As shown in Fig. 1, the proposed model showed that the notable impacts of software quality, software security, software interoperability, and effort expectancy explained 0.95% of the variance in performance expectancy, while 91% of the variance in behavioral intention to use open source software was found to be demonstrable by performance expectancy, software cost, social influence, self-efficiency, and facilitating conditions. The behavioral intention arose as a significant predictor of actual usage by demonstrating 0.56% of its variance. All these findings are consistent with findings in prior researches (Safadi et al. 2015; Venkatesh et al. 2003; Shin 2010; Glynn et al. 2005). Even though very few studies have investigated the causal paths between software interoperability and cost with the behavioral intention and performance expectancy, which was done in this study.

The study contributed positively and discovered that IT specialty impacts as a moderator on the relationships among the constructs of the models proposed. Furthermore, the results also presented the influence of IT specialty on open source software acceptance. Interestingly, the open source software acceptance increases among IT specialists due to their ability to access and customize the source code, improving software security, performance, and usability. Moreover, the free cost of installation and low cost of implementation, infrastructure availability, and the opinions of other people (instructors, colleagues, and boss) are important factors to increase the open source software acceptance among the IT specialists. Thus, open source software developers and organizations should take all of these factors into account in their development and implementation. Additionally, the IT specialists as end-users should be involved in the software development methodologies of open source software.

A recent study of Ibrahim and Adamu (2018) also supports the present study results, which was conducted to identify the challenges in operating the OSS. It also explored four main strategies that were employed in the companies, including pooled R&D product, spinouts, attracting complements, and selling complements. It suggested the implementation of the identified strategies in other industries for acquiring broad outcomes of OSS. These strategies were useful for the software firms to assist the innovation within the firm, externally and internally. Additionally, research regarding the OSS characteristics was conducted within the South African context and discovered the contribution of some key factors; such as technological support,

Table 5 The result of moderating effects

Path	IT specialists	IT generalists	Support
H1b: BI ← PE	0.406***	0.488***	No
H2b: BI ← EE	-0.142	0.159	No
H5b: BI ← FC	0.135**	0.089	Yes
H8b: PE ← SEC	0.268***	0.123	Yes
New BI ← SI	0.474***	0.080	Yes
New BI ← COS	0.285***	0.162	Yes

*p < 0.05, **p < 0.01, ***p < 0.001

technological freedom, and control, adoption, environmental and organizational factors (Moolman 2011). However, the study also focused on the implication of decision factors.

The proposed integrated model can also be applied in firms and businesses to formulate a strategic plan for the effective implementation of the systems. The organizations and firms can maximize and optimize the profits using open source software and its cost-efficiency. For applying this OSS, the management of the firm needs to observe the behavior of the end-user and shape it accordingly. The findings regarding the influential roles of software quality, software security, software cost, usefulness, ease of use, facilitating conditions, social influence, and self-efficacy in determining the user intention revealed that organizations should invest more effort in improving users' perceptions of such factors.

7 Conclusion

Although few researches have investigated the user acceptance of open source software, no study provided a comprehensive analysis of user acceptance model that integrated open source software characteristics with infrastructure and social factors. Thus, the present study bridged this gap and proposed a comprehensive user acceptance model integrating OSS characteristics, infrastructure, individuals, and social factors. It is also the first study that investigates the validity of UTAUT in the OSS context. The results of the study conclude that Effort Expectancy (EE) has a positive and significant impact on the Performance Expectancy (PE); where PE has a positive and significant impact on the Behavioral Intention (BI) to use the OSS. It showed that BI had positive and significant influence toward Actual Usage (ACU). These results implicate that the application of open source software systems requires less effort and is useful over similar closed software. This research work also found a significant relationship between Social Influence (SI), Self-Efficacy (SE), Facilitating Condition (FC), and implementation Cost (COS) with the Behavioral Intention (BI). Thereby, it can be interpreted that users believe that individual in their firm should facilitate them with the OSS implementation due to different factors. These include the perception that; they have self-confidence in using OSS; they have enough resources and knowledge to use OSS; their organizations recognize the implementation cost of OSS. The software

Interoperability (INT), Software Quality (SQ), software Security (SEC) were found to have a positive and significant effect on the Performance Expectancy (PE). These findings suggest that the users perceive that OSS compatibility with other software for information exchange can improve its functionality. This implies that users find that the quality and security of OSS could enhance the OSS functionality; reduce the problems associated with OSS usage; and overcome the security concerns.

This research work also discovered the effect of IT specialty as a moderator on the relationships among the proposed model constructs. Interestingly, the open source software acceptance increases among the IT specialists due to their ability to access the source code and to customize it for enhancing its quality and compatibility with the users' needs.

On the other hand, the results of this research work provide some fundamental practical implications for developers, individual as well as organizational users. The individuals and organizations recognize the cost efficiency and low efforts for OSS implementation for supporting their daily tasks. Secondly, in order to implement an OSS system, the organizations and individuals should consider infrastructure availability and the opinions of other people (instructors, colleagues, and boss) when OSS is being implemented. The OSS developers and organizations should consider some software characteristics that are important for users acceptance of OSS; such as, software interoperability, software quality, and software security concerning the development and implementation of OSS.

The results of this research work are statistically significant, and the proposed methodology provided painstaking attention. However, there are some limitations, including the data which was collected from users of both private and public organizations. The findings could be different if the study distinguishes between the two types of organizations. This can be analyzed by further researches to support this research and to provide better understanding related to OSS acceptance. Furthermore, this research work integrated the OSS characteristics, social, infrastructure, and individual factors with UTAUT constructs to investigate the acceptance of OSS. Moreover, future research can examine the validity of other acceptance theories and models such as the technology acceptance model (TAM) in the same context for enhancing the research domain.

Appendix: Items of survey instrument

Variables	Items	Source	Cronbach's alpha
Performance expectancy (PE)		Venkatesh et al. (2003)	0.87
	PE1: Using OSS would enable me to accomplish my work (learning) tasks more quickly		
	PE2: I would find OSS useful in my work (learning)		
	PE3: Using OSS would increase my productivity		
	PE4: Using OSS would increase my chances of getting a raise		
Effort expectancy (EE)		Venkatesh et al. (2003)	0.87
	EE1: Learning how to use OSS would be easy for me		
	EE2: My interaction with OSS would be clear and understandable		
	EE3: It would be easy for me to become skilful at using OSS		
	EE4: I would find OSS easy to use		
Software quality (SQ)		Park and Del Pobil (2013)	0.91
	SQ1: use of OSS would enhance the functionality of applications that I use		
	SQ2: use of OSS would decrease the number of errors in use my computer		
	SQ3: use of OSS requires less maintenance		
	SQ4: I have not had any limitations or problems with using OSS		
	SQ5: OSS fully meet my needs		
Security (Sec)		Shin (2010); Yenisey et al. (2005).	0.98
	Sec1: I believe that my privacy is protected at OSS		
	Sec2: I'm confident that the operation at OSS is secure		
	Sec3: I believe nobody can access my private data saved at OSS without my agreement		
	Sec4: OSS does not share my personal information with Others		
Social influence (SI)		Venkatesh et al. (2003)	0.80
	SI1: I will use OSS, if the people who are important to me think I should use it		
	SI2: I will use OSS, if the people who influence my behaviour think I should use it		
	SI3: I will use OSS, if the instructors of my learning helpful in the use of such systems		
	SI4: People in my organization who use OSS have more prestige than those do not		
	SI5: In general, I would find my organizations has supported using OSS		
Facilitating conditions (FC)		Venkatesh et al. (2003)	0.92
	FC1: I have the resources necessary to use OSS.		
	FC2: I have the knowledge necessary to use OSS		
	FC3: The OSS is compatible with other systems I use		
	FC4: A specific person (group) is available for assistance with OSS difficulties		
Self-efficacy (SE)		Ong et al. (2004)	0.94
	SE1: I am confident to use the OSS if I have just built-in help facility for assistance		
	SE2: I am confident to use the OSS If I have a lot of time to accomplish the tasks for which a system is provided		
	SE3: I am confident to use the OSS if there is no one around to show me how to do it		
	SE4: I am confident to use the OSS as long as someone shows me how to do it		
Cost		Chan et al. (2008)	0.86
	Cos1: The implementation cost of OSS will be free or low		
	Cos2: effort cost of moving to OSS will be free or low		
	Cos3: Switching to OSS might not lead to monetary problems		
	Cos4: OSS are reasonably priced comparing with proprietary software		
	Cos5: In general, OSS are a good value for the money		

Variables	Items	Source	Cronbach's alpha
Interoperability (Int)		Almeida et al. (2011); Gortney (2016); Wilson (1994)	0.74
Int1: OSS can provide services to and accept services from other systems			
Int2: OSS can receive and process intelligible information of mutual interest transmitted by another service's system			
Int3: Using OSS would enable me to save my documents in many formats			
Int4: Using OSS would enable me to receive information with any formats			
Int5: In general, OSS can interact with other systems and exchange data with it			
Behavioural Intention (BI)		Šumak et al. (2011); Zhang et al. (2008)	0.82
BI1: I intend to use OSS to improve my work or learning			
BI2: I predict to use the OSS when it implemented			
BI3: I plan to use the OSS when it implemented			
BI4: I expect to use the OSS when it implemented			
BI5: I would strongly recommend my colleagues to use OSS			

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