



British Journal of Applied Science & Technology
4(34): 4816-4834, 2014
ISSN: 2231-0843



SCIECEDOMAIN *international*
www.sciencedomain.org

Evaluating the Adoption of Open Source Software

M. K. Mijinyawa¹ and L. Abdulwahab^{2*}

¹*School of Information Systems, Computing and Mathematics, Brunel University, Uxbridge, UK.*

²*Department of Information Technology, Bayero University, Kano, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2014/12504

Editor(s):

(1) Sunday Olusanya Olatunji, College of Computer Science and Engineering, King Fahd University of Petroleum & Minerals, Saudi Arabia.

Reviewers:

(1) Anonymous, Yamaguchi University, Japan.

(2) M. Bhanu Sridhar, Department of CSE, GVP College of Engineering, Vizag, India.

Complete Peer review History: <http://www.sciencedomain.org/review-history.php?iid=671&id=5&aid=6237>

Original Research Article

Received 2nd July 2014
Accepted 21st August 2014
Published 27th September 2014

ABSTRACT

The understanding of the viability, competitiveness, and challenges of using open source software has important implications for the understanding of its adoption. However, one important problem is the paucity of contextual, valid and generalizable frameworks for understanding the adoption of open source software. In contributing to address this important issue, this paper presents a theory-grounded framework for understanding factors and their influence in the adoption of open source software. The framework has been developed based on the decomposed theory of planned behavior (DTPB), through the augmentation of the research areas of the adoption of open source software and the adoption of information and communication technology (ICT) in small businesses. We show that the exploratory and explanatory capabilities of the framework provides simple concepts for researchers seeking to develop valid and generalizable research models and

*Corresponding author: E-mail: abd_wahhb@yahoo.com;

analysis instruments, and for practitioners seek common understanding of factors influencing their adoption of open source software. Implications of the framework are discussed within the contexts of direct utilization, as justifications for intervention, and as frame of reference for understanding and communicating issues influencing the adoption of open source software. The paper outlines proposals for future research to extend and validate the analytical capabilities of the framework.

Keywords: Open source software; innovation adoption; information technology; technology acceptance; decomposed theory of planned behavior; organizational change.

1. INTRODUCTION

There is a growing popularity of open source software (open source) as an important part of organizational ICT infrastructure [1,2,3,4]. The term open source as used in this paper refers to OSS as software where the license model grants individuals, groups, and organizations extensive rights to use, modify, and redistribute the binary and source-code of the original and modified/derived works, without requiring license royalty fees (Open Source Initiative – OSI, Open Source Definition – OSD version 1.9). While most open source projects and communities comply with this definition, there may be some differences in licensing terms and conditions, particularly in relation to dual-licensing and re-distribution of source code (see, http://en.wikipedia.org/wiki/Comparison_of_free_software_licenses).

The adoption of open source has been discussed in many contexts including large enterprises [5,6,7], public sector areas [8], developing economies [9,10,4] and health-care industry [9,11,12]. The characteristics of individuals, small businesses, large organizations, and government bodies differ, and influence the adoption of ICT in general. Therefore, different open source adoption contexts are likely influenced by varying sets of factors, including organizational characteristics. For instance, while cost saving as an economic benefit may be attractive in small businesses, management and decision-makers in large organizations are likely not motivated by the relative cost saving from using royalty-free open source licenses. Rather, the time saving and reduced administrative overhead of license auditing, and the enhanced agility in the access to, and the ease of, adopting new open source solutions are likely relevant in most organizations.

To ascertain the scope of organizational contexts of open source adoption, we have chosen a small businesses context, informed by the literature of small business adoption of ICT in general and literature of the adoption of open source. Consistently, study suggests that organizational characteristics of small businesses influencing their adoption of ICT in general (see, for examples, [13,14,15,16]), likely influences their adoption of open source. The term open source adoption, as used in the paper, refers to the process through which an adopter passes from first knowledge of the open source, to forming attitudes towards its use, to decisions to use or reject it, its implementation, and to confirmation of this decision (adapted from [17,18,19]).

Studies suggests that factors influencing the adoption of open source are complex and subjective [20,2,6]. Contextual frameworks, related models, theories, guidance, etc. helping researchers and practitioners to better identify complex and subjective influencing factors and understand their influence are important to managers and other practitioners in small businesses, who are likely to benefit from the use of open source and the participation in

open source projects and communities, and often face challenges in their adoption of ICT in general [21,22,13].

However, a paucity of valid and generalizable theories in the area of open source adoption [5,11] indicates that there are limitations in the current knowledge and understanding of the potential benefits, challenges, etc. and their influence on the adoption of open source in small businesses. These limitations means that researchers and practitioners face challenges in their understanding and evaluations of the adoption of open source in small businesses. This gap in research has led us to the broad question: what factors influence the adoption of open source in small businesses and why? In addressing this question, this paper presents a theory-grounded framework for exploring and understanding factors influencing the adoption of open source. In doing so, the key objectives of the paper are, (1) to identify and collate illustrative factors relevant to the adoption of open source in small businesses, and (2) to model valid and generalizable explanations of the illustrative factors and their influence on open source adoption.

To deliver these objectives, there are four major sections that form the structure of the rest of the paper. The next section explores the early studies of open source adoption to outline an important limitation in the understanding of influencing factors in this context, arguing for the use of a theory-grounded approach for doing so. Section 3 will present the operationalization of a selected theory – the decomposed theory of planned behavior (DTPB) – to develop a framework of the adoption of open source. Following that, the research and practice implications of the framework, its limitations and related suggestions for future research are discussed in the section “Discussions”. The last section will present concluding remarks about the work presented in the paper.

2. THEORETICAL FOUNDATION

Scholars have discussed diverse factors influencing open source adoption in terms of benefits including cost saving [9,1,2,8], functionality [7] and quality characteristics [23,24,7]; barriers such as a lack of drivers [25,6] and limited support from government bodies [26,27,4,16]; and facilitators and inhibitors such as innovativeness [5,26,13], capital investment [22,28,15], IT infrastructure [29,30] and staff IT-capacity [26,11,16]. As illustrated in Fig. 1, this diversity in categories and types suggests that influencing factors are complex. Again, open source adoption has been discussed in diverse contexts such as health-care industry [9,11,12], developing economies [9,10,4], large enterprises [5,6,7], and public sector areas [8]. The set of influencing factors prevalent in these diverse areas of use likely differ, suggesting that open source adoption are subjective to the adoption settings. Therefore, it is important to use relevant theoretical frameworks for analyzing complex and subjective factors and understanding their influence on the adoption of open source.

2.1 Limitations in the Understanding of Factors Influencing the Adoption of Open Source

Early studies have discussed factors influencing open source adoption using mainly the technology and organization and environment contexts (see, for examples, [5,9,31,31,7]). Such contexts together provides a parsimonious framework for semantic categorization of factors influencing the adoption of an innovation [7] (see, an illustrative framework in Fig. 1). However, study suggests the semantic contexts used in Fig. 1 lack construct validity [5]. For instance, diverse factors such as cost saving and functionality and trialability are categorized

under a common context. The complexity and subjectivity of influencing factors implies that analysis and explanations of such factors within a single context, and using these seemingly monolithic concepts, are likely to face limitations of validity and generalizability [33,19].

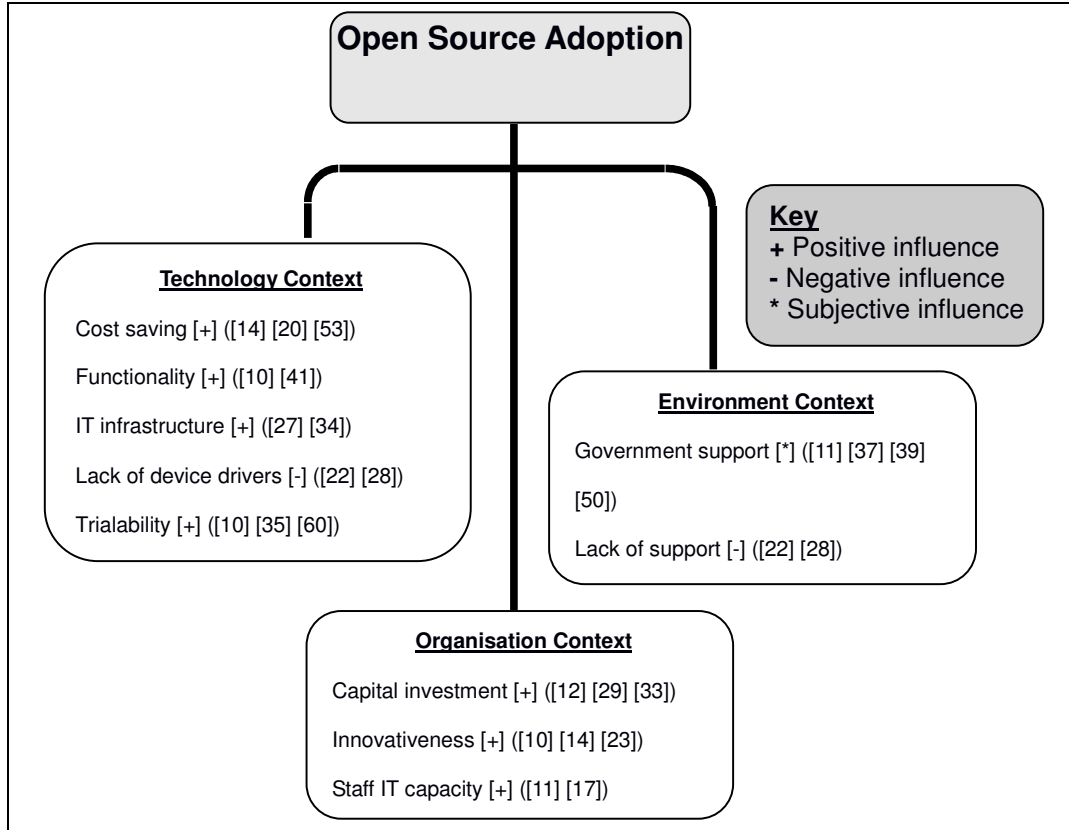


Fig. 1. Semantic framework of factors influencing the adoption of open source

Another limitation in Fig. 1 is that as a parsimonious framework, it lacks exploratory and explanatory capabilities. The exploratory and explanatory capabilities are relevant in dealing with complex and subjective illustrative factors, and for explaining the nature and influences of the factors on open source adoption. This limitation implies that the framework in Fig. 1 is unsuitable for the objectives set-out in this paper.

Relatively, widely-accepted behavioral and ICT adoption theories in the IS field provide diverse constructs and within their nomological network for exploring factors and explaining their influence on adoption. Consistently, studies suggests that use of reliable and widely-accepted theory-grounded concepts with established construct validity, generalizability and better exploratory and explanatory capabilities improves the validity and generalizability of analysis, understanding, research models, and conclusions drawn from related findings [33,34,19]. These assertions have led to us undertaking an evaluation of existing theories relevant to the adoption of ICT in general.

2.2 Evaluation of Common Theory-grounded Frameworks of Adoption

Many studies in the field of information systems have applied validated ICT adoption models and theories to enhance the reliability of their research design and the validity and generalizability of empirical findings (see, for examples, [35,36,37]). However, the research area of open source adoption is still in its infancy [5,11], reflected in the paucity of theory application. The evaluation and application of widely used and validated ICT adoption models and theories is important in advancing theory application in this developing research area. This reason has led to us evaluating relevant ICT adoption models and theories and selecting a theory most suitable for addressing the already discussed limitations.

The theories being evaluated are summarized in Table 1, and based on a common beliefs-intention-behavior structure. This structure can be seen as representing the exploratory and explanatory capabilities in each model and theory in Table 1. A comparison of the exploratory and explanatory capabilities of the theories has led to the selection of the decomposed theory of planned behavior (DTPB). Three key reasons justifying this selection will now be discussed.

Table 1. Comparison of relevant models and theories of ICT adoption

Theories	Determinants of Intention			Scope of decomposition	References
Decomposed Theory of Planned Behavior (DTPB)	Attitude	Subjective norms	Perceived behavioral control	All determinants of intention	[19]
Theory of Planned Behavior (TPB)	Attitude	Subjective norms	Perceived behavioral control	N/A	[38]
Technology Acceptance Model (TAM)	Attitude	N/A	N/A	Attitude	[34]
Theory of Reasoned Action (TRA)	Attitude	Subjective norms	N/A	N/A	[39]

The first reason is that the DTPB and the 'pure' TPB, as shown in Table 1, comprise of all three key determinants of intention and therefore has better exploratory capabilities [38,19]. This advantage over other models and theories is relevant for exploring a broad scope of complex and subjective influencing factors, and it enhances both the exploratory and the explanatory capabilities of a research model.

The second reason, as illustrated in Table 1, is that the DTPB has its determinants of intention decomposed into their belief structures [40,19]. This decomposition extends the exploratory capabilities of the DTPB over the other theories, providing simpler decomposed structures to identify complex factors more accurately and therefore, enabling better analysis and explanations of their influence.

Finally, prior studies have compared the theories in Table 1 and concluded that the DTPB has the most exploratory and explanatory capabilities, but was the most complex and least parsimonious [35,36,41]. Furthermore, this theory has been applied in empirical studies, and it has been recommended as a useful theory for exploring organizational-level adoption of ICT in general [40,37,19]. These issues are relevant to our objectives which focus on the organizational-level of the adoption of open source in small businesses.

3. CONCEPTUALIZING THE ADOPTION OF OPEN SOURCE USING THE DTPB

Having justified the selection of the DTPB, this theory is operationalized in the context of open source adoption, as illustrated in Fig. 2. The operationalization applies the illustrative factors – summarized in Table 2 – from the literature of open source adoption, and of ICT adoption in general to provide context to the operationalization of the DTPB theoretical constructs. The operationalization leads to related hypotheses that explains the influence of the theoretical constructs on the adoption of open source.

3.1 Framing Actual Use of Open Source

The actual use of open source is represented by the behavior concept, and refers to the implementation of an open source and the confirmation of its use (adapted from [17,18,19]). The definitions of adoption suggests that it is a multi-stage decision process. As illustrated in Fig. 2, the stages of beliefs, intention, and behavior allow us to explain adoption. Fig. 2 also shows that actual use can be inhibited by the influence of the perceived behavioral control; this relationship is discussed in detail in section 3.5. The theoretical constructs associated with the stages will now be discussed.

3.2 Framing Intention to Use Open Source

As illustrated in Fig. 2, intention is the immediate determinant of behavior. It is defined as the evaluations or judgment that using an open source is good or bad for the organization (adapted from [38,34,19]). Here evaluations or judgment refers to the combined influences of the three belief components (attitude and subjective norms and perceived behavioral control), which are relevant in framing explanations of the influence of factors on open source adoption and therefore, will be operationalized as well. Thus, we propose that *(H1) the intention to use an open source has a positive influence on actual use.*

3.3 Framing Attitude Towards the Use of Open Source

The first belief component in Fig. 2 is attitude, defined as the perceptions (and evaluations or judgment) that the use of an open source is favorable or unfavorable to an adopter (adapted from [38,33,39,19]). This suggests that attitude is formed from the influence of perceptions favorable and those unfavorable to use. The DTPB posits that attitude has a direct influence on intention [38,19]. Thus, favorable attitude towards use of open source, which is seen as an important part of organizations' information and communication infrastructure [2,3,4], has a positive influence on intentions to its use. This understanding has led to the proposition that *(H2) attitude towards use of an open source has a positive influence on intention.*

Attitude is likely the strongest determinant of intention [36,37,19] and it is decomposed in the DTPB as attitudinal belief structures (relative advantage, complexity and compatibility). We considered that other constructs related to issues of attitudinal beliefs were relevant in the context of open source adoption, and therefore sought to extend the exploratory and explanatory capability of attitude in the DTPB. In so doing, we extended the decomposition of attitude using other related belief structures, as illustrated in Fig. 2. All of the attitudinal belief structures in Fig. 2 will now be operationalized.

Table 2. Operationalized belief structures and related contextual factors

Belief structures	Analytical features	Contextual factors	Triangulation of literature
Affect	Emotions of liking, elation, joy, pleasure, depression, disgust, displeasure and hate	Enjoyment of use, participation and challenging	[3,42,43,44]
Anxiety	Apprehensive, fear/phobia, hesitation and intimidation	Unreasonable fears	[9,25,45]
Compatibility	Existing value, previous experiences or current needs	Functionality	[24,46,7]
Complexity	Difficult to understand, learn or use	Lack of support	[5,25,6]
Image	Enhancement to image or status	Prestige	[1,31,42]
Relative advantages	Economic benefits, convenience, satisfaction and performance	Cost saving	[9,20,2]
Result demonstrability	Tangibility of results, observability and communicability	Demonstrability	[6,10,4,8]
Trialability	Experimentation before actual use	Trialability	[5,1,30]
Visibility	Visible and communicable	Visibility	[1,11,31]
Voluntariness of use	Voluntary or free will	Voluntariness	[10,4]
Peer influences	Peers such as friends, families and colleagues	Consultants and vendors	[22,47]
Superior influences	Information from secondary sources	Government support	[4,8]
Self-efficacy	Personal/internal ability or confidence	Innovativeness IT capacity	[9,1] [11,25]
Resource facilitating conditions	Time and money resources	Capital investments	[23,24,48]
Technology facilitating conditions	Technology compatibility and infrastructure	IT infrastructure	[29,30]

3.3.1 Affect towards use

Affect is the first attitudinal belief structure in Fig. 2, and we define it as feelings of joy, elation and pleasure or depression, disgust, displeasure and hate towards use of open source (adapted from [49]). Study suggests that open source adopters enjoy the use, the

creativity, and the participation in projects and communities [43], and the challenging activities of software development, maintenance, distribution, and governance [3,42,44]. These views suggest that enjoyment in the use of open source is a positive affect (see, similar contexts, [50,41]). Communicating issues of affect in the use of open source, is likely to draw the attention of practitioners in small businesses, who are seen as innovative and often, early adopters of new technology [13,47]. This context of affects leads to propose that, (H2a) affect has a positive influence on attitude.

3.3.2 Anxiety in use

Anxiety is the second belief structure in Fig. 2 and we define it as the tendency to be uneasy, apprehensive and phobic towards use of open source (adapted from [51]). This construct enables identifying issues of perceived risks and unreasonable fears likely to be relevant to new adopters, and those in early stages of the adoption, of open source. For example, fear has been discussed as an issue discouraging new users to trial open source ([9,45]); and discussed in terms of the growing and hidden costs of IT projects, and the fear that the open source community will splinter or disappear [25]. Much has been discussed about the 'FUD' concepts used by industry competitors to induce fear, uncertainty and doubt (FUD) about the viability and competitiveness of open source solutions. In contrast, there have been arguments suggesting that fear of litigation from use, copying and redistribution of open source are unreasonable [31]. This discussion leads to the following proposition: **(H2b) anxiety has a negative influence on attitude.**

3.3.3 Compatibility of use

The third attitudinal belief structure in Fig. 2 is compatibility, defined as the degree to which an open source fits with an adopter's existing values, previous experiences or current needs (adapted from [52,18,19]). Small businesses may find the flexibility of open source [31] appealing to their organizational structures and innovativeness [13,47]. Consistently, study suggests that an open source would be more appealing to adopters if its functionality in terms of capability and usefulness meets their business values and needs [24,7]. These contexts fits with the compatibility feature of existing values or needs. Therefore, the functionality of open source is a compatibility factor, and this has a positive influence on adoption. Based on this argument, the following proposition is offered: **(H2c) compatibility has a positive influence on attitude.**

3.3.4 Complexity in use

The fourth attitudinal belief structure in Fig. 2 is complexity, defined as the degree to which an adopter perceives an open source to be difficult to use, learn or understand (adapted from [18,19]). Small business are often regarded as lacking highly skilled staff to provide in-house support for ICT adoption [47,16] and therefore adopters in such organizations may lack the staff capacity to address problems in using open source (see, for other contexts of lack of support [5,25,6]). This example fits with the feature of the difficulty of use. This understanding has led to the proposition that **(H2d) complexity has a negative influence on attitude.**

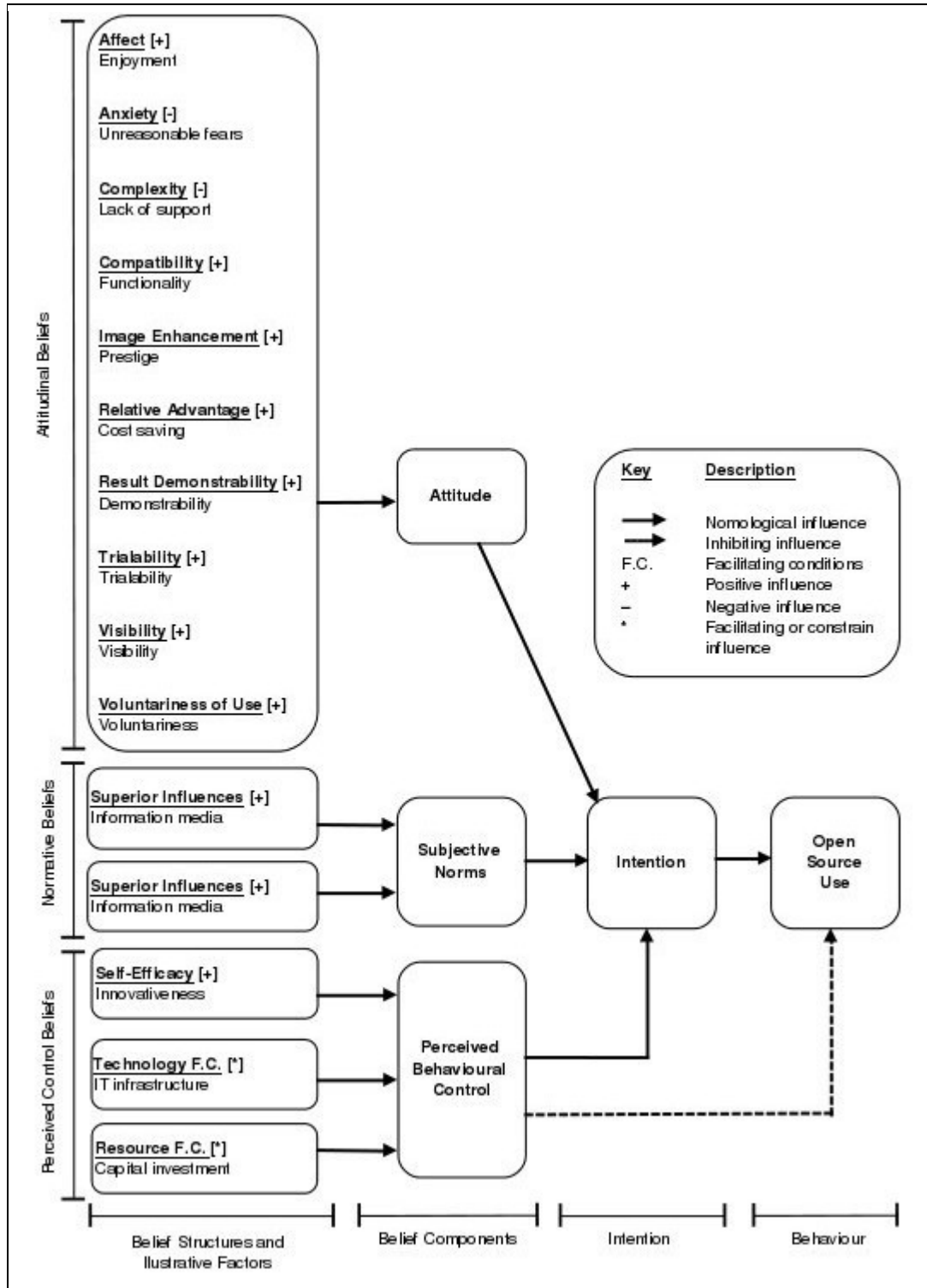


Fig. 2. Framework for evaluation of open source adoption

3.3.5 Image enhancement from use

Image enhancement is the fifth attitudinal belief structure in Fig. 2. This construct is defined as the degree to which the use of an open source is perceived to enhance the image or status of the adopter in their social system (adapted from [35,52]). Owing to their technical supremacy and contributions in resources and skills, individuals, developers, organizations, open source movements and advocates, and major contributors hold high status of good reputation, high prestige and gratification, peer recognition and respect, and trust in open source and the wider IT communities, than their closed-source counterparts [1,53,31,42]. On the other hand, staffs in a small business may feel that their jobs are under-valued if mandated to use free software, particularly when such management action is aimed at addressing shrinking IT budgets and scarce financial resources to support ICT use [1,31]. Based on these discussions, we propose that *(H2e) image enhancement has a positive influence on attitude.*

3.3.6 Relative advantage from use

The sixth attitudinal belief structure in Fig. 2 is relative advantage, defined as the degree to which an open source provides benefits including economic benefits, image enhancement, convenience, satisfaction and performance, which supersede those of its precursor (adapted from [34,18,19]). Studies suggests cost saving is perceived as economic benefit motivating the use of open source. The zero cost of open source licenses offers adopters saving on software license costs [9,20,2,54], which may be relevant in small businesses sensitive to the need for capital investment in ICT adoption in general [22,32,28]. Based on this discussion, we propose that *(H2f) relative advantages have a positive influence on attitude.* This proposition explains the influence of relative advantages on attitude towards use.

3.3.7 Result demonstrability of use

Result demonstrability is the seventh attitudinal belief structure in Fig. 2. This construct is defined as the degree of tangibility of the results of using an open source, including their observability and communicability (adapted from [52]). Use of open source has been observed in different contexts: in large enterprises [6,15]; public sector areas [8]; developing economies [9,10,4]; and in the health-care industry [1,11]. The observation and communication of the results of use of open source in these contexts likely draws the attention of potential seeking to understand and to justify how open source may be of value to them and their organizations. Based on these arguments, we propose that *(H2g) result demonstrability has a positive influence on attitude.*

3.3.8 Trialability of use

Trialability is the eighth belief structure in Fig. 2, and defined as the degree to which an open source may be experimented with before adoption (adapted from [52]). Trialability in the context of open source adoption seemingly has a broader scope than that commonly associated with the trial of a proprietary software because there are no restrictions in the trial of features and functionalities of an open source [5,1], no vendor mandated time-limit on trials, no restrictions in the trial of multiple open source licenses, and no restriction of the trial of full support from open source communities (see, the Open Source Definition – OSD Version 1.9). Trialability is an important factor, allowing adopters the trial of an open source (OSD Version 1.9) to determine its suitability for their needs and organizational values. The satisfactory results of potentially long running trials and evaluations may lead to a committed

use and future use of an open source [30]. Similar approach has been applied in evaluation of the viability and competitiveness of open source in a range of government departments and public bodies [31,6,10,8]. These contexts of trialability are consistent with the view that innovations are more likely to be adopted if the potential adopter is able to trial and experiment with it to ascertain its usefulness [18]. This understanding leads to the following proposition: **(H2h)** *trialability has a positive influence on attitude.*

3.3.9 Voluntariness of use

As shown in Fig. 2, the ninth attitudinal belief structure is voluntariness of use, defined as the degree to which the use of an open source is perceived as being voluntary or of free will (adapted from [52]). The features of this concept suggests that use of particular open source can be mandatory or voluntary in different settings. Organizations may have IT policies selectively mandating the use of particular systems including open source for reasons including leveraging the open source brand [20], gaining greater IT independence and promoting software code transparency [10,4]. The understanding of issues related to voluntariness of use may help decision-makers and managers address staff resistance to change [5,11], especially when migrating to open source platform, and may be useful in promoting voluntary experimentation and exploration of the benefits of using open source. Based on these views, we propose that **(H2i)** *voluntariness has a positive influence on attitude.*

3.3.10 Visibility of use

Finally, we define the belief structure, visibility of use, as the degree to which open source and its use are visible and communicable to others (adapted from [52]). Study suggests that visibility can influence adoption in the contexts of its current use and its future use [55] and this is likely relevant to potential adopters who may gain awareness from seeing and learning about new open source solutions. This implies two perspectives to visibility: a software perspective associated with the openness of open source applications and source code (OSD Version 1.9 – criteria 1, 2, 3 and 4), and a use perspective in relation to experiencing the use of open source solutions through access to open source LiveCD, video demonstrations, software benchmarks etc. However, the similarity of user-interfaces and applications (for examples, in mobile phones platforms and auto-navigation systems from third-party software vendors) has led to arguments that users may not differentiate between the open source and closed-source applications they are using [1]. Based on these discussions, we propose that **(H2j)** *visibility has a positive influence on attitude.*

3.4 Framing Subjective Norms around the Use of Open Source

The second belief component in Fig. 2 is subjective norms, defined as the perception of the social pressures on a potential adopter to use or not use an open source (adapted from [38,39,19]). Examples of social pressure from referent groups includes the influences of work colleagues, media services, government support, vendors and consultants [27,4,16,8], within the social environment of the open source adopter. Subjective norms enables identifying and understanding such influencing factors within the social environments of small businesses adopting open source. Based on these discussions, we propose that **(H3)** *subjective norms have a positive influence on intention.* This proposition explains the influence of subjective norms around the use of open source on intentions about its use by the adopter.

The diversity of referent groups suggests they are likely to have varying influence on a potential adopter's decisions to use, or not use an open source. The two belief structures of the subjective norm – peer influences and superior influences – provide simpler concepts for differentiating between referent groups and their influence.

3.4.1 Peer influence on use

Peer influence is defined as the perception that peers such as friends, families and colleagues influence the normative beliefs that using an open source is good or bad for the adopter (adapted from [19]). Study suggests that government legislations, such as measures to enforce the conformity to intellectual property laws [4,8], might drive organizations seeking to avoid the additional costs in license auditing and management to consider more use of open source solutions. Although consultants and vendors generally provide facilities and professional information to aid innovation adoption, and they are often seen as knowledgeable and trusted on the subject of ICT adoption [22,47], managers in small businesses (such as a family-owned small businesses) may feel pressured to comply with the advice of consultants and vendors, and they may have concerns about their independence in making decision about IT implementation [13], and about receiving inadequate and ineffective facilities and information [22,47] from such external players. These issues suggests that peers influence including consultants and vendors, and government policies are generally geared towards advancing the use of innovations such as open source. This discussion leads to the proposition that (H3a) peer influence have a positive influence on normative beliefs.

3.4.2 Superior influence around use

The second normative belief structure in Fig. 2 is superior influences, defined as the perception that information from secondary sources, such as news on the Internet, TV and newspapers influence the normative beliefs that using an open source is good or bad for the adopter (adapted from [38,19]). Consistently, communication channels are important elements in the spread and diffusion of innovations [18]. The Internet is an important information media and communication channel for the adoption and diffusion of open source. Adopters may find the Internet useful as a primary source of open source communities and projects, support services, and software products. Based on these arguments, we propose that (**H3b**) *superior influence have a positive influence on normative beliefs.*

3.5 Framing Perceived Control over Use of Open Source

The third belief component in Fig. 2 is perceived behavioral control and is defined as perceptions of the control over the personal/internal and external factors that facilitate or constrain the use of open source (adapted from [38,19]). This belief component is relevant in exploring and understanding organizational readiness in the adoption of open source. Based on these discussions, we propose that (**H4**) *perceived control over the use has a positive influence on intention.*

The DTPB provides three belief structures (including self-efficacy, resource facilitating conditions, and technology facilitating conditions) to enable easier identification of diverse issues related to perceived behavioral control.

3.5.1 Self-efficacy for use

The first belief structure is self-efficacy, defined as an adopter's personal/internal ability or confidence to use an open source successfully (adapted from [19]). Study suggests that subjects with self-assured skills and confidence to use an open source are more inclined to adopt it [38,19]. In this context, innovativeness has been discussed in terms of the confidence of top management and change agents [13,27] to support the trial and motivate continued use of an open source by staff in their organization [9,1]. Based on these discussions, we offer the following proposition: **(H4a)** *self-efficacy has a positive influence on perceived control.*

3.5.2 Resource facilitating condition for use

The second perceived control belief structure is resource facilitating conditions, defined as the supporting resources, such as time and money that facilitate or constrain the use of open source (adapted from [19]). The features of time and money provide useful context for discussing resource facilitating conditions of capital investments and staff-time for supporting the use of open source. Capital investment has been discussed as an important issue associated with the costs of learning and switching, adaptation, re-distribution, integration and maintenance of ICT [23,24,48]. These issues are likely to be relevant to small businesses adoption of open source. From a time resources perspective, limitations in staff-time or a lack of the staff capability for in-house support may drive organizations to use scarce financial resources in outsourcing support, a recurring issue in small businesses adoption of ICT in general [22,28,15]. Based on these discussions, we propose that **(H4b)** *resource facilitating conditions have a positive influence on perceived control.*

3.5.3 Technology facilitating condition for use

Finally, technology facilitating conditions is defined as the technology compatibility issues that facilitate or constrain the use of an open source (adapted from [19]). For instance, relevant IT infrastructures such as computer systems, network hardware, and Internet connection may be essential for use of software technologies including open source [29], [30] in particular adoption settings. Based on this perspective, we offer the following proposition: **(H4c)** *technology facilitating conditions have a positive influence on perceived control.*

Although facilitating conditions influence the perceived control over use of an open source, which contributes to the intentions to use, the influence do not guarantee actual use. On the other hand, as illustrated in Fig. 2, a lack of essential facilitating conditions for adoption may inhibit actual use (adapted from [19,41]). Therefore, issues related to essential facilitating conditions may represent an adopter's critical failure factors. For example, the challenges of limited financial and human resources, and the external influences of ICT vendors (such as vendor products and services lock-in, and industry monopoly) may constrain an adopters flexibility and choices in the migration to, and continued use of, open source solutions [26], [54]. Based on this argument, we propose that (H5) lack of facilitating conditions has a negative influence on actual use.

4. DISCUSSION

This paper has presented a theory-grounded framework for evaluating factors and understanding their influence on the adoption of open source. This contribution is important

and addresses broad questions regarding factors influencing the adoption of open source and explanations helping to understand their influence in this context. The exploratory capabilities of the framework illustrated in Fig. 2 has shown that open source adoption in small businesses may be influenced by complex and subjective factors related to attitude towards use, subjective norms around use, and perceived behavioral control over use. Its explanatory capabilities were demonstrated using relationships between its belief components, the intention and the behavior constructs to explain the influence of diverse illustrative factors identified in the literature. The framework extends the existing knowledge and understanding of factors and their influence and contributes to addressing the paucity of theory-grounded and contextual frameworks for the evaluation of open source adoption in small businesses [11].

The validity and generalizability of the underlying theory – the DTPB – and other theoretical concepts applied allows us to argue that the framework is generalizable for studies of open source adoption in other contexts, as well as the adoption of ICT in general. The generalizability of the framework is important, enabling a common understanding of factors and their influence across studies and evaluations of the adoption of open source in general. Generally, frameworks are important contributions in the developing research area of open source adoption [1,11,6]. Three implications for research and practice will now be discussed, focusing on the issues of direct utilization, frame of reference, and justification for course of action [35,33]. Following that, limitations in the framework are discussed, and we propose related future research.

4.1 Implications for Research and Practice

The theory-grounded framework presented in the paper has direct utilisability for evaluating factors and understanding their influence in the adoption of open source. The validity and generalizability of the underlying theory (the DTPB) and the extended attitudinal belief structures should give confidence to researchers seeking to apply the framework in their studies. For the same reasons, practitioners may find the framework useful as an underlying component, in whole or in part, for their field evaluation of open source adoption.

Second, the framework is useful as a general frames of reference [55,17] for understanding factors and related theoretical concepts relevant to the adoption of open source in small businesses. The factors applied in the operationalization of the framework provide a general view of the diverse technological, organizational and environmental issues that may influence the adoption of open source in small businesses. Researchers and practitioners may find the discussions of illustrative factors useful as references for better understanding the complexity and subjectivity of similar influencing factors in the adoption of open source in their research and organizational settings.

Finally, the arguments to support the operationalization of the framework provide useful justifications for consideration in the selection of contextually relevant theoretical concepts [33]. The research area of open source adoption in small businesses is still emerging [5,1,6] and there is a paucity of valid and generalizable frameworks helping researchers and practitioners to identify and understand influencing factors. Practitioners may find the arguments useful in selecting theoretical concepts relevant to decisions-making and strategy about the adoption of open source in their organizations.

4.2 Limitations and Proposed Future Research

The theory-grounded conceptual framework presented in the paper is exploratory, and has its limitations. Generally, conceptual models have limitations of empirical validity in their representation of characteristics of an innovation and its adoption [35,17,6]. Therefore, the framework presented in the paper has similar limitations. However, the framework presented in the paper was developed based on validated and widely-accepted theoretical concepts of the DTPB and other innovation characteristics. Studies have applied the DTPB and similar innovation characteristics implemented in the framework, and many have reported useful research findings (see, for examples, [40,37,19]). This limitation paves the way for future research as a confirmatory study to validate the operationalized theoretical concepts of the framework and the related hypotheses. The following list illustrates six test questions relevant to advancing the understanding of open source adoption.

Test questions for future research and confirmatory study

1. To what extent might the framework be valid and reliable for evaluating the adoption of open source?
2. How well might the framework predict the attitudes, subjective norms and perceived control over use in the adoption of OSS?
3. What theoretical constructs and concepts might be most significant in understanding factors influencing the adoption of open source? Such constructs and concepts provide a research focus for exploring related contextual factors relevant to the adoption of open source.
4. What theoretical constructs might be considered as part of a set of a critical success factors?
5. Is the explanatory capability of the framework stable and reliable across the greater majority of the sample population?
6. What theoretical constructs and concepts are likely to have important implications of theoretical generalizability beyond the context of the adoption of open source?

Results from such study and tests may contribute to ascertaining the validity and reliability of the framework as an analysis tool for evaluation of factors influencing the adoption open source.

Another limitation of the framework is related to its scope of theoretical concepts [17,29,52]. The framework was operationalized within the context of the adoption of open source in small businesses, and therefore may lack other theoretical constructs prevalent in other ICT adoption settings. However, the generalizability of the underlying DTPB and innovation characteristics makes the framework flexible for extensions to improve its exploratory and explanatory capabilities, or a reduction in its scope to enhance parsimony. In this context, future research may seek to determine the significance of the underlying theoretical concepts of the framework, and may cull non-significant concepts to improve its parsimony when used in similar contexts or other areas of the adoption of ICT in general.

5. CONCLUSION

This paper has presented a theory-grounded framework for evaluating the adoption of open source in small businesses. The theory-grounded approach applied in developing the framework shows that valid and generalizable theories of innovation adoption allow to better

analyze and understand complex and subjective influencing factors. An augmentation of the literature of the general ICT adoption in small businesses, the adoption of open source and the models and theories of organizational adoption of technology appears to be a credible way to frame theoretical concepts for valid analysis and common understanding of the adoption of open source in small businesses. This approach in the analysis of prior literature was relevant, partly, because the research of open source adoption is still in its infancy. The paucity of theory-grounded frameworks in this research area also necessitated the extension of the DTPB in the framework to accommodate additional innovation characteristics relevant for understanding open source adoption. However, doing so has allowed to enhance the exploratory and explanatory capabilities of the framework for simpler analysis and understanding of influencing factors. The paper appears to be among the first applying an extended DTPB to model the adoption of open source, and in so doing contributes to addressing the paucity of valid and theory-grounded frameworks in this developing research area. The wide scope and generalizability of the framework suggests that it has important implications for research and practice, and we have proposed future research to test its validity and reliability for evaluations of the adoption of open source in small businesses.

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Fitzgerald B. Open source software adoption: Anatomy of success and failure. *International Journal of Open Source Software & Processes*. 2009;1(1):1–23.
2. Forrester Consulting. Open Source Software's expanding role in the enterprise: Helping Business Thrive on Technology Change; 2007. Accessed 20 July 2012. Available:http://www.unisys.com/eprise/main/admin/corporate/doc/Forrester_research-open_source_buying_behaviors.pdf
3. Lakhani KR, von Hippel E. How open source software works: 'free' user-to-user assistance. *Research Policy*. 2003;32(6):923–943.
4. Mindel JL, Mui L, Verma S. Open source software adoption in ASEAN member countries. *Proceedings of the 40th Hawaii International Conference on System Sciences*; 2007.
5. Dedrick J, West J. Why firms adopt Open Source platforms: A grounded theory of innovation and standards adoption. *Standard Making a Critical Research Frontier for Information Systems*. MISQ Special Issue Workshop, Seattle. 2003;236–257.
6. Holck J, Larsen MH, Pedersen, MK. Managerial and technical barriers to the adoption of open source software. *Proceedings of the 4th International Conference on COTS Based Software Systems*. February; Bilbao Spain; 2005.

7. Overby, EM, Bhardwaj AS, Bhardwaj SG. An investigation of firm-level Open Source Software adoption: theoretical and practical implications. In: R. K. Jain, editor. Open Source Software in business – issues and perspectives. Hyderabad, India: ICFAI University Press. 2006. Accessed 5 May 2008.
Available:http://userwww.service.emory.edu/~eoverby/files/overby_open_source_adoption_study.pdf
8. Valimaki M, Oksanen V, Laine J. An empirical look at the problems of open source adoption in Finnish municipalities. ICEC, 2005. Xi'an China; 2005.
9. Ellis J, Belle JP. Open source software adoption by South African MSEs: Barriers and enablers. SACLA 09, Mpekwani Beach Resort, South Africa; 2009.
10. Kshetri N. Economics of Linux adoption in developing countries: developing with Open Source Software. IEEE Software. 2004;23:74–81.
11. Fitzgerald B, Kenny T. Open source software in the trenches: Lessons from a large-scale OSS implementation. Twenty-Fourth International Conference on Information Systems; 2003.
12. Pare G, Wybo MD, Delannoy C. Barriers to open source software adoption in Quebec's health care organizations. J Med Syst. 2009;33:1–7.
13. Gelinas R, Bigras Y. The characteristics and features of SMEs: Favorable or unfavorable logistics integration. Journal of Small Business Management. 2004;42(3):263–278.
14. Macredie RD, Mijinyawa K. A theory grounded framework of open source software adoption in SME's. European Journal of Information Systems. 2011;20:237–250.
15. Robert J, Buhman C, Garcia S, Allinder D. Bringing COTS information technology into small manufacturing enterprises. H. Erdogmus, T. Weng, editors. Proceedings of the 2nd International Conference on COTS-Based Software Systems (ICCBSS'03), LNCS; 2003.
16. Stockdale R, Standing C. Benefits and barriers of electronic marketplace participation: an SME perspective. Journal of Enterprise Information Management. 2004;17(4):301–311.
17. Benbasat I, Moore GC. Development of measures for studying emerging technologies. Proceedings of the Twenty-Fifth Hawaii International Conference on Systems Science (HICSS); 1992.
18. Rogers EM. Diffusion of innovations. 4th ed. NY: The Free Press; 1995.
19. Taylor S, Todd P. Understanding information technology usage: A test of competing models. Information Systems Research. 1995;6(2):144–176.
20. Fitzgerald B. The transformation of open source software. MIS Quarterly. 2006;30(3):1–6.
21. Darch H, Lucas T. Training as an e-commerce enabler. Journal of Workplace Learning. 2002;14(4):148–55.
22. Dutta S, Evrard P. Information technology and organisation within European small enterprises. European Management Journal. 1999;17(3):239–251.
23. Bonaccorsi A, Giannangeli S, Rossi C. Entry strategies under competing standards: Hybrid Business Models in the Open Source Software Industry. Management Science. 2006; 52(7):1085–1098.
24. Economides N, Katsamakas E. Two-sided competition of proprietary vs. Open source technology platforms and the implications for the software industry. Management Science. 2006;52(7):1057–1071.
25. Geira J. The cost and risks of open source: Helping business thrive on technology change. Best Practices – Forrester. 2004;2–14.

26. Duan Y, Mullins R, Hambin D, Stane S, Sroka H, Machado V, Araujo J. Addressing ICTs skill challenges in SMEs: Insights from three country investigations. *Journal of European Industrial Training*. 2002;26(9):430–441.
27. Martin L. Internet adoption and use in small forms: Internal processes, organisational culture and the roles of the owner-manager and key staff. *New Technology, Work and Employment*. 2005;20(3):190–204.
28. Kumar S, Krishnan MS. Impact of open source software adoption on firm IT expenditure. *Workshop on Information Systems and Economics, Irvine, California*. 2005;1–5.
29. Holck J, Larsen MH, Pedersen MK. Identifying business barriers and enablers for the adoption of open source software. *ISD 2004, Vilnius, Lithuania*. 2004;10:1–15 (working paper).
30. Kwan SK, West J. A conceptual model for enterprise adoption of Open Source Software. In: B. Sherrie, editor. *The Standards Edge: Open Season*. Ann Arbor, Mich: Sheridan Books; 2005.
31. Glynn E, Fitzgerald B, Exton C. Commercial adoption of open source software: An empirical study. *Proceedings of International Symposium on Empirical Software Engineering, Noosa Heads, Australia*; 2005.
32. Houghton KA, Winklhofer H, Ennew C. Factors affecting the adoption of the Internet for global marketing in UK exporting SMEs: development of a conceptual model. *The 30th EMAC Conference, Bergen, Norway*; 2001 (Paper submitted for consideration).
33. Benbasat I, Zmud RW. Empirical research in information systems: The practice of relevance. *MIS Quarterly*. 1999;23(1):3–16.
34. Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*. 1989;13(3):319–339.
35. Agarwal R. Individual acceptance of information technologies. In: R. W. Zmud, editor. *Framing the domains of IT management: Projecting the future from the past*. Pinnaflex Educational Resources, Cincinnati. 2000;85–104.
36. Lin HF. Predicting consumer intentions to shop online: An empirical test of competing theories. *Electronic Commerce Research and Applications*. 2007;6:433–442.
37. Shih Y, Fang K. The use of a decomposed-theory of planned behaviour to study Internet banking in Taiwan. *Internet Research*. 2004;14(3):213–223.
38. Ajzen I. Theory of planned behaviour. *Organisational Behaviour and Human Decision Processes*. 1991;50:179–211.
39. Fishbein M, Ajzen I. *Belief, attitude, intentions and behaviour: An Introduction to Theory and Research*. MA: Addison Wesley; 1975.
40. Hsu M, Chiu C. Predicting electronic service continuance with a decomposed theory of planned behavior. *Behavior and Information Technology*. 2004;23(5):359–373.
41. Venkatesh V, Morris MG, Davis GB, Davis FD. User acceptance of information technology: Toward a unified view. *MIS Quarterly*. 2003;27(3):425–478.
42. Sen R, Subramaniam C, Nelson ML. Determinants of the choice of open source software license. *Journal of Management Information Systems*. 2009;25(3):207–239.
43. Snow CC, Strauss DR, Culpa R. Community of firms: A new collaborative paradigm for open innovation and an analysis of Blade.org. *Int. J. Strategic Business Alliances*. 2009;1(1):53–72.
44. Wu CG, Garlach JH, Young CE. An empirical analysis of open source software developers' motivations and continuance intentions. *Information & Management*. 2007;44:253–262.
45. Goode S. Something for nothing: Management rejection of open source software in Australia's top firms. *Information & Management*. 2005;42:669–681.

46. Gallego MD, Luna P, Bueno S. User acceptance model of open source software. *Computers in Human Behavior*. 2008;24:2199–2216.
47. Martin LM, Matlay H. Innovative use of the internet in established small firms. *Qualitative Market Research: An International Journal*. 2003;6(1):18–26.
48. Haefliger S, von Krogh G, Spaeth S. Code reuse in open source software. *Management Science*. 2008;54(1):180–193.
49. Thompson RL, Higgins CA, Howell JM. Personal computing: Toward a conceptual model of utilization. *MIS Quarterly*. 2009;15(1):124–143.
50. Compeau DR, Higgins CA, Huff S. Social cognitive theory and individual reactions to computing technology: A longitudinal study. *MIS Quarterly*. 2009;23(2):145–158.
51. Igbaria M, Chakrabarti M. Computer anxiety and attitudes toward microcomputer use. *Behaviour & Information Technology*. 1990;9:229–241.
52. Moore GC, Benbasat I. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research*. 1991;2(3):192–222.
53. Fitzgerald B, Agerfalk PJ. The mysteries of Open Source Software: Black and white and red all over? *Proceedings of the Thirty-Eighth Hawaii International Conference on System Sciences (HICSS-38)*, IEEE Computer Society Press; 2005.
54. von Krogh G, von Hippel E. The promise of research on Open Source Software. *Management Science*. 2006;52(7):975–983.
55. Agarwal R, Prasad P. The role of innovation characteristics and perceived voluntariness in the acceptance of information technologies. *Decision Sciences*. 1997;28(3):57–582.

© 2014 Mijinyawa and Abdulwahab; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<http://www.sciencedomain.org/review-history.php?iid=671&id=5&aid=6237>