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A Review of Prominent Technology Acceptance Models in the Context of Predicting Software Adoption in African Developing Countries: A Case of Free Desktop Open Source Software (OSS)

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Abstract: A number of technology adoption models have been developed over the years. Currently, there are ten prominent models which since, their development have been tested in different environments. The models have also been extended by including constructs which researchers perceive to be important depending on the environment. The models are Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Motivational Model (MM), Theory of Planned Behavior (TPB), Combined TAM and TBP, Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT), Social Cognitive Theory (SCT), Unified Theory of Acceptance and Use of Technology (UTAUT) and the Extended Unified Theory of Acceptance and Use of Technology (EUTAUT). Generally these models have been developed and tested in non-African and non-developing countries. This study reviews these prominent existing technology adoption models with the aim of establishing their appropriateness in predicting Desktop Open Source Software (OSS) adoption in developing countries in Africa.

Key words: Free Desktop Open Source Software, technology adoption models, information systems, social cognitive theory, innovation, TBP

INTRODUCTION

Envisaging reasons why people embrace or reject information systems is one of the most challenging and complex issues in information systems research (Swanson, 1974). Low adoption of computers and information systems is a widespread problem in organizations and in society (Buabeng-Andoh, 2012; Davis *et al*., 1989). Different technology adoption models have been applied in different environments in an effort to predict technology adoption in that environment. It is important to understand why individuals adopt or resist using computers in order to develop workable ways of evaluating computer systems, "predicting how users will respond to them" and to respond appropriately by improving the "nature of systems and the processes by which they are implemented" (Davis *et al*., 1989).

In the opinion by Venkatesh *et al*. (2003) there are ten prominent technology acceptance models which are Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Motivational Model (MM), Theory of Planned Behavior (TPB), combined TAM and TBP, Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT), Social Cognitive Theory (SCT), Unified Theory of Acceptance and Use of Technology (UTAUT) and the Extended Unified Theory of Acceptance and Use of Technology (EUTAUT). Each of these technology acceptance models varies in one way or another from the others. The main difference between the competing models is their constructs (Venkatesh *et al*., 2003). Venkatesh *et al*. (2003), further explain that some of the models such as TRA and TPB stem from psychology and others from sociology but have been applied in predicting technology acceptance. They further opine that choosing the most appropriate model for a scenario is normally challenging for researchers as they have a "multitude" of models to choose from.

In order to make technology adoption prediction easier for researchers, Venkatesh *et al*. (2003) developed a unified model that "Integrates elements across the eight models" (Venkatesh *et al*., 2003). Although, they developed this unified model, a recent study indicated that the model "explained about 70% variance in behavioural intention to use a technology and about 50% of the variance in technology use" (Venkatesh *et al*., 2012). They further established that studies that applied UTAUT in some cases dropped some of its constructs or its moderators in order to apply it in a specific context. They noted that UTAUT was not adequate in predicting adoption in a consumer technology use context. A study

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that sought to understand technology adoption in an education set-up established that UTAUT is applicable to some extent but needed a few modifications to fit in that context (Akbar, 2013). Venkatesh *et al.* (2012) developed an extended model of UTAUT in which they included the constructs hedonic motivation, price value and habit. The extended model was tested in a mobile internet consumer's environment in China.

African countries differ in economic and cultural aspects from other countries in other continents. African countries in general have economic challenges with the majority of people in sub-Saharan Africa living on less than $1.25 a day (United Nations, 2014). Different countries have different cultures especially in the areas of power distance, individualism and masculinity (Hofstede, 1984). A study conducted by Hofstede (1984), revealed that African countries differed culturally from North American ones. Countries in one region could also share a general culture, for example, Great Britain has England, Scotland and Wales which generally share a common culture (McSweeney, 2002).

Developing countries have their own dynamics compared to developed countries such as the USA and China where the majority of the models were developed. The culture in developing countries is quite different from that of developed countries. The social economic status of individuals in developed countries is quite different from that of developing counties. The generalisability of the models as proved by some reviewed studies is highly questionable due to the cross-cultural and psychometric differences (Straub *et al.*, 1997; Igbaria, 1993; Anandarajan *et al.*, 2002; Saade *et al.*, 2009).

Uptake of ICT has been low in most African countries (WEF, 2016). The WEF (2016) noted that one major barrier of ICT adoption in sub-Saharan Africa is affordability. In Africa, computer users who are likely to voluntarily adopt ICT such as university students in Kenya hardly afford computers (Kashorda and Waema, 2014). Availability of skills and infrastructure are also significant barriers of ICT adoption in sub-Saharan Africa (WEF, 2016).

Information systems technology adoption literature indicates that during the development of the existing technology acceptance models, empirical studies were mainly conducted in North America using American subjects (Anandarajan *et al.*, 2002). Anandarajan *et al.* (2002), further argue that a change of cultural context requires modified information technology and management practices. For instance, a study conducted in Africa by Anandarajan *et al.* (2002) whose aim was to examine the applicability of the Technology Adoption Model (TAM), revealed that there was a disparity in the results in the African set-up compared to the North American one. The disparity in the results according to Anandarajan *et al.* (2002) was caused by the difference in the national culture. The study also noted that there was a general disparity between less developed countries such as African ones with the developed countries in North America in terms of applicability of technology adoption theories. The findings by Anandarajan *et al.* (2002) are consistent with those by Brown (2002) who concluded that TAM does not apply in the same way in a developing country as it was developed with a developed country in mind.

A model that satisfactorily predicts the adoption of free desktop OSS in African developing countries would need to take into account economic and cultural aspects. The model would also need to take into account the usability and the level of skill required in order to use the software.

Taking into account cultural and economic differences between African and developed countries this study therefore aims to review the prominent models and related studies with the view of enhancing understanding on adoption of desktop OSS in an African setup. In particular, this study seeks to establish the degree and nature of application of the existing technology adoption models in this context. Based on review of available literature, there are very limited studies that have holistically assessed application of the above models in developing countries in Africa which further qualifies this study. The study also aims to infer if there are other influencing variables besides the prominent model's constructs in relation to contextual differences.

MATERIALS AND METHODS

Review of common technology adoption theories

Diffusion of Innovations (DoI): The DoI was first published by Rogers in 1962 in a book entitled Diffusion of Innovations (Rogers, 1995). Although, the researcher refers to the theory as diffusion of innovations in many publications the theory is referred to as Innovations Diffusion Theory (IDT). The researcher developed the theory by synthesizing the existing studies which according to him were about 405 in number. There have been amendments into the theory by the same researcher which according to him are based on newer empirical research reports and publications. The changes have been widely accepted by other researchers and applied in research.

DoI identifies five attributes of an innovation that influence the adoption and acceptance behaviour which are relative advantage, complexity, compatibility,trialability and observability. Rogers (1995)

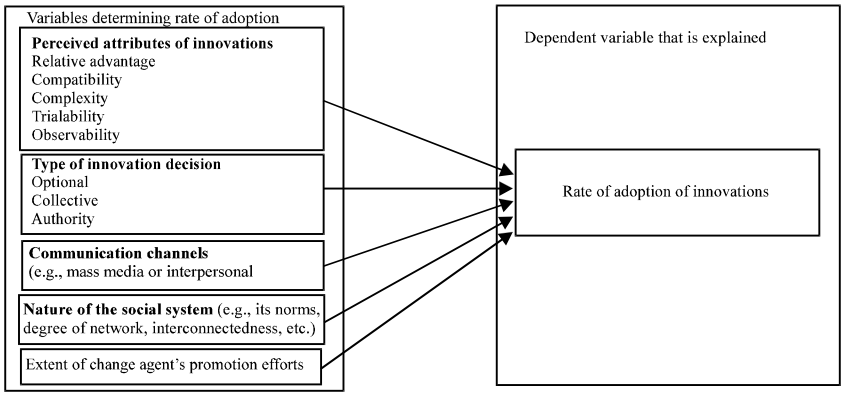

Fig. 1: The diffusion of innovations (Fishbein and Ajzen, 1975)

developed a conceptual framework showing the variables that determine the rate of adoption of an innovation which is shown in Fig. 1.

Rogers (1995) reports that the first research on attributes of innovation was conducted with farmers although according to Rogers (1995), a similar study of teachers and school administrators by Holloway (1977), gave the same results. The study on attributes of innovation with 100 high school principals had factor analysed Likert-type scale questions measuring respondent's perceptions of fresh educational ideas to develop the attributes (Holloway, 1977). The study identified relative advantage, complexity, compatibility, trialability and observability as the attributes of innovations although, according to Rogers (1995), the distinction between relative advantage and compatibility was not very clear-cut.

Rogers (1995) reports that individuals generally adopt optional innovations more rapidly than when an innovation is adopted by an organization and argues that the more individuals involved in adopting an innovation the slower the rate of adoption. In addition, the degree of interconnectedness of a communication network structure of a social system also affects the rate of adoption of an innovation as well as the promotion efforts made by the change agents.

Application of DoI in information systems research: DoI has been used and adapted in various research studies such as e-Business, e-Procurement, enterprise resource planning, web site, intranet, materials requirements planning among other areas (Oliveira and Martins, 2011). The theory is one of the common models that are used in studying adoption and post adoption behaviours in ICT (Al-Mamary *et al*., 2016). In this research, the model has been used to predict and explain use of innovation and diffusion behaviours by consumers in multiple disciplines (Jen *et al*., 2009; Rambocas and Arjoon, 2012). In the development of UTAUT, tests that were conducted using DoI demonstrated that relative advantage which is similar to performance expectancy was the most significant predictor of intention (Venkatesh *et al*., 2003). The same study established that ease of use which is equivalent to complexity and effort expectancy is significant in both voluntary and mandatory settings before the users gain knowledge to use the technology.

DoI has been used to identify the determinants of internet banking by young customers in Trinidad and Tobago (Rambocas and Arjoon, 2012). The study extended the DoI Model to include government support and consumer trust. The study established that perceived relative advantage was the most significant determinant of internet banking loyalty followed by government support to a lesser extent (Rambocas and Arjoon, 2012).

In Uganda DoI has been used to investigate the adoption of internet as an innovation (Paul *et al*., 2015). The study noted that the predictors of internet adoption are compatibility, relative advantage, trialability and complexity. Relative advantage of the internet was found to be the most significant factor contributing to internet adoption in rural urban areas of Uganda.

Limitations of DoI: There are limited literature and studies discussing the limitations of DoI especially in the area of information technology. The researcher notes that the theory is rich in terms of the social factors contributing to the adoption of a technology such as the nature of social system and change agent's promotion efforts.

Experience in using a technology is an important factor that contributes to the adoption of a similar technology. This factor is salient in a number

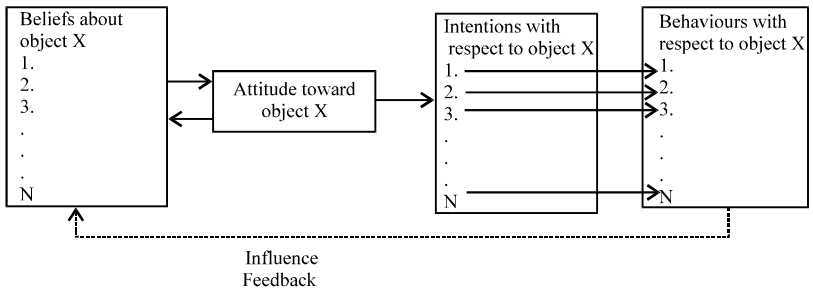

Fig. 2: Theory of reasoned action

of technology adoption theories and features prominently in the UTAUT. In DoI experience does not feature anywhere probably because it is assumed that no one has experience in using a new innovation. This fact is not true for information technology/systems because if one has used similar software before, he/she is likely to have an easier time when using the new one. The DoI theory seems to have been developed purposely for new technological innovations and is not best suited for predicting OSS adoption in developing countries such as Africa.

Theory of Reasoned Action (TRA): The theory of reasoned action was developed by first developing a conceptual framework where beliefs were a fundamental building block in the field of psychology (Fishbein and Ajzen, 1975). This conceptual framework was grounded on empirical studies conducted by other researchers. According to Fishbein and Ajzen (1975), the totality of an individual's beliefs serves as the informational base that finally determines his attitudes, intentions and behaviours. Their conceptual framework also suggests that a person's attitude towards an object is related to the set of his beliefs about the object but not necessarily to any particular belief. They further argued that attitude towards an object will usually not be related to any specific intention with respect to the object. In their view, attitude is a general tendency that does not influence the person to perform any specific behaviour but rather leads to a set of intentions that indicate a certain amount of affect towards the object in question. Their study was based on the conceptual framework shown in Fig. 2.

According to Fishbein and Ajzen (1975), attitude can be measured using a measurement procedure whereby a person assigns some concept to a position on a bipolar evaluative dimension. In the bipolar measurement, a scale such as the one shown in Fig. 3 is used.

On the other hand in order to measure belief, the attribute that is linked to the object is identified first,because a belief associates an object and an attribute (Fishbein and Ajzen, 1975). For example cleanliness as a belief can be measured with the attributes,

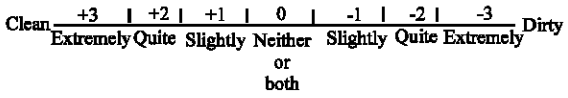

Fig. 3: Bipolar measurement scale

very clean, clean, dirty, etc. The attribute can then be measured using a bipolar scale. According to them, most beliefs are shaped on the basis of direct observation which provides information to an individual which in turn influences their beliefs towards an object. They further argued that a person's attitude is related to the totality of his beliefs but not automatically to any specific belief he holds. Intention to perform a specified behaviour relates to particular kinds of attitudes and beliefs namely attitudes toward the behaviour and subjective norms concerning performance of the behaviour. They further noted that there is a systematic set of relationships linking beliefs to attitudes, attitudes to intentions and intentions to behaviour and finally an individual can form new beliefs only by performing some behaviour. According to them in order for a person to change beliefs, intentions, attitudes and behaviours the individual has to be exposed to information and an environment which produces changes in some of his beliefs.

Application of TRA in information systems research: TRA is an imported theory because it was not specifically developed to be used in information systems research (Moody *et al*., 2010). The theory has been used in different disciplines and in a variety of studies such as condom use dieting, consumption of genetically modified foods etc. (Hoffmann *et al*., 1999). Studies in information systems have widely adopted the theory on the basis that adoption is an attitude issue which can be studied using TRA (Otieno *et al*., 2016).

TRA has been applied in the area of internet banking as a technology in Malaysia to determine factors that influence an individual's intention to use a technology (Nor *et al*., 2008). The study supported TRA by confirming that an 'individual behaviour intention to use

Internet banking is influenced by their attitude and subjective norm' (Nor *et al*., 2008). A study conducted in America that applied TRA in the area of social networking established that attitude and subjective norm influence intention to use social networking. The study however, noted that although subjective norm influences intention it does not have a direct influence on behaviour.

All the studies discussed above based the intention to use information systems on attitude and subjective norm. Application of TRA in information systems studies ignores other important factors such as perceived ease of use and perceived usefulness which are significant in the adoption of information systems. TRA has not been used extensively to evaluate technology adoption but mainly to conceptualise the behavioural pattern of an individual in decision making on the adoption of a technology or innovation (Otieno *et al*., 2016). TRA is also referred to as an intention based model and has been used by many researchers to investigate the relationship between attitude and intention. Information systems literature has demonstrated that TRA has only been used in scenarios where the theory identify user's behaviours and attitudes in issues relating to online buying, internet use, household computer use and online privacy (Otieno *et al*., 2016).

Some studies have combined TRA and TAM in order to improve the prediction power of TRA. A study conducted in Australia to predict mobile phone usage banking behaviour employed both the constructs of TRA and those of TAM such as perceived usefulness and ease of use in order to improve on both theories. Another study by, conducted in South Africa that sought to predict the attitude of retail banking customers towards internet banking services equally applied constructs of both TRA and TAM.

TRA has been used in the prediction of digital piracy among the youths in South Africa. Although, this study largely employed the constructs of TRA, the study borrowed constructs such as personal values from other models to make it more predictive. Many other studies around the world in areas of electronic management adoption, adherence to information security policies, predicting user trust on information systems just to mention a few have introduced additional constructs into TRA to improve on the model .

Limitations of the Theory of Reasoned Action (TRA): One of the limitations of the model that was highlighted by the researchers is that the theory was developed to deal with behaviours (e.g., buying a car) and not outcomes or events that result from behaviours (e.g., losing weight) (Sheppard *et al*., 1988). According to them, the model deals with only those behaviours that are under a person's volitional control and consequently, actions that are at least partially determined by factors beyond individual's voluntary control fall outside the boundary conditions established for the model. They further noted that the model is not suitable to study goals for which attainment involves a degree of uncertainty and in cases where a person is presented with several choices. This is because many of the attributes and results linked with various substitutes in the choice set are apt to be somewhat alike.

The TRA Model is largely based on the argument that beliefs influence behaviour only via. their indirect influence on attitudes which has been challenged by other researchers. A study conducted by Davis *et al*. (1989) established that attitudes do not fully mediate the effect of perceived usefulness and perceived ease of use on behaviour. They further observed that the conceptualization of subjective norm based on TRA has theoretical and psychometric problems.

The TRA theory would need additional constructs to make it more suitable for explaining the use behaviour of computer systems in general and in particular adoption of desktop OSS Software.

Social Cognitive Theory (SCT): The theory was developed by Bandura (1982) and is founded on a causal model of triadic reciprocal causation. In this model, personal factors in the form of cognitive, affective and biological events, behavioural patterns and environmental events wholly function as interacting determinants that influence one another bidirectionally (Bandura, 1999). According to Bandura (1982), human behaviour is commonly explained in terms of unidirectional causation in which behaviour is represented as either being formed and governed by environmental influence or driven by internal dispositions.

The social cognitive theory was developed from studies conducted in the area of psychology by Bandura *et al*. (1961). In a study that aimed to demonstrate that people learn from watching others, a series of experiments involving 72 children participants were conducted using a Bobo doll (Bandura *et al*., 1961). The study consisted of three experiments which aimed at demonstrating how children imitate aggressive behaviours from adults. In the experiments, the children were exposed to aggression, non-aggression and mild aggression environments. The results of these experiments revealed that children in the aggressive conditions exhibited more aggressive behaviour than

those in the non-aggressive conditions with boys performing more aggressive behaviour than girls in the same conditions (Bandura *et al*., 1961).

Application of SCT in information systems research: The SCT theory is regarded common in the area of information systems (Venkatesh *et al*., 2003). SCT has been applied to a wide range of areas of study such as career choice, mental and physical health organisational behaviour (Al-Mamary *et al*., 2016). The theory can also be applied to areas of internet usage and gratification as well as computer utilisation (Al-Mamary *et al*., 2016).

SCT's concept of self-efficacy has been used in the study of end-user training in computing (Compeau and Higgins, 1995). The results of their study did not support outcome expectations although the study noted that SCT is applicable to the training context but needed some adjustments.

Another study applied SCT to investigate self-regulated learning using a web-based learning system called Netports (Wang and Lin, 2007). The study revealed that self-efficacy and collective efficacy contribute to student's learning behaviours. The study by Wang and Lin (2007) validated the use of SCT to predict web based learning while using the Netports system.

SCT was applied in a study that sought to understand the adoption behaviour of Australian youths towards mobile banking (Ratten and Ratten, 2007). The study established that the youths are influenced by media exposure and outcome values to adopt the technology. The study however established that self-efficacy, outcome expectancy and modelling of others were insignificant in this scenario (Ratten and Ratten, 2007).

Another study that explored the social cognitive determinants and examined their associations with social media usage employed SCT (Khang *et al*., 2014). The social cognitive determinants considered in this study were: self-efficacy, habit, self-regulation and past experiences. The study established that habit was the most significant determinant of social media usage because people use social media in a habitual manner (Khang *et al*., 2014).

In the development of UTAUT, tests were conducted to examine the constructs of SCT. The study demonstrated that outcome expectations was a strong predictor to usage intentions for both first time users and afterwards (Venkatesh *et al*., 2003). The study established that, during first time use of a technology, self-efficacy and anxiety were significant determinants of intention but nonsignificant over time. SCT has also been applied in Botswana to investigate the relationship between computer self-efficacy and general self-efficacy, computer anxiety, locus of control and academic self-esteem (Mogotsi, 2013). The study found all the factors investigated related to computer self-efficacy. Self-efficacy construct of SCT has been employed to measure the impact of ICT in teaching experiences on two different groups in a study conducted in both Brazil and South Africa. (Fanni *et al*., 2013). One of the studies confirmed the role of self-efficacy in relation to teaching experiences while the other did not.

Limitations of Social Cognitive Theory: A good number of information systems studies have been conducted applying the social cognitive theory while investigating individual behaviour (Carillo, 2010). Although, the model has been used in IS research, the model lacks in a number of ways. The model does not have constructs relating to the attributes of the IS product being investigated but rather concentrates on social influence and other social aspects that influence an individual's behavioural intention (Ratten and Ratten, 2007).

The model lacks constructs such as the usability of the product being used. This study established that the reason for this omission is that the model was not originally developed to study technology adoption behaviour but to study other behaviour in the field of psychology. This study noted that the model is suited to predict adoption of a technology through the learning and training process as demonstrated in the literature reviewed.

This study established that the SCT Model would need more constructs to make the model more appropriate for predicting OSS adoption behaviour in developing countries.

Technology Acceptance Model (TAM): TAM is a widely cited and used model that seeks to explain the reasons why people accept or reject technology (Davis, 1989). The development of the model was based on some theoretical foundations such as the impact of perceived usefulness on system utilization which was proposed by the research of. TAM also borrowed from the self-efficacy theory, the channel disposition model, the cost-benefit paradigm, behavioural decision theory among others. The different theories were in agreement that perceived usefulness and ease of use are significant determinants of behaviour (Davis, 1989).

The model was developed by first conducting a pilot study which involved 112 users in order to refine the data collection instrument (Davis, 1989). The pilot study concerned two different interactive computer systems. After the pilot study, the data collection instrument was

streamlined in order to evaluate the six item usefulness and ease of use scales. A second study was then conducted involving 40 participants and two graphics systems (Davis, 1989). Data from the two studies was then used to examine the relationship between usefulness, ease of use and reported usage. The study established that both perceived usefulness and ease of use are significantly correlated with self-reported indicators of system use. The study further revealed that usefulness was considerably more strongly related to usage than was ease of use.

Application of TAM in information systems research: TAM is one of the most tested acceptance models in a variety of information technologies (Yousafzai *et al*., 2007). Empirical studies have found that TAM is a robust and powerful model that explains a fair proportion of the variance in usage intentions and behaviour (Venkatesh and Davis, 1996). TAM is also regarded as a stronger model than TRA and it is much simpler and easier to use (Igbaria, 1993).

TAM has been tested in the adoption of learning technologies in Korea using the LISREL program. The study, established that TAM is a good theoretical model that would help understand users acceptance of e-Learning. The study however included the constructs e-Learning self-efficacy, subjective norm and system accessibility into TAM in order to improve on the model and make it more predictable in this context.

A study conducted in the US that sought to establish how attitudes determine internet usage employed TAM with additional constructs. Age, education, income perceived access barriers and race were added to TAM as external variables which resulted to a stronger model. The study established that the basic constructs of TAM: perceived ease of use and perceived usefulness were important constructs in the context of internet use. The additional constructs to TAM perceived access barriers and the external variables were also found to be significant in the study.

A study conducted in Nigeria on general use of computers which employed TAM established that perceived usefulness and perceived enjoyment do not motivate individuals to use computers in a less developed country such as Nigeria (Anandarajan *et al*., 2002). The study further established that social pressure and organisational support are significant determinants of microcomputer technology adoption. Anandarajan *et al*. (2002) noted that the findings were different from those conducted in America because of the differences in national culture. Although, the literature of TAM suggests that research results are convergent, Averweg (2010) notes that there are scenarios where they are conflicting. Another cross cultural study conducted in three developing countries; Saudi Arabia, Malaysia and South Africa revealed that TAM was suitable in Saudi Arabia and Malaysia but not in South Africa (Averweg, 2010). Averweg (2010) suggests the inclusion of variables related to human and social change processes to TAM in order to make it a more robust model.

A cross-cultural test of TAM (on e-Mail technology adoption) in the US, Switzerland and in Japan proved that TAM did not hold in Japan indicating that the model may not predict technology use across all cultures (Straub *et al*., 1997). In the study, Straub *et al*. (1997) noted that in Japan there was a culture of avoiding uncertainty, being assertive, great distances of power between managers and workers and collectivist sentiments which limited e-Mail use which was not the case in Switzerland and America.

The above are just a few case scenarios where TAM has been applied in IS adoption studies. TAM has been extended to the adoption of email, voice mail, graphics, personal computer, computer applications, the World Wide Web, telemedicine technology, debugging tools, among other areas (Yousafzai *et al*., 2007; Legris *et al*., 2003). A meta-analysis of TAM as applied in research conducted by Legris *et al*. (2003) reviewed a total of 22 studies in different countries. Out of the 22 studies reviewed, only 6 had purely applied TAM as a model in the studies. The majority of the studies (16) had incorporated other models such as TRA and TPB while other studies had incorporated additional constructs such as subjective norm, perceived behavioural control, social norms, etc. (Legris *et al*., 2003). The study further noted that although, TAM is a good model it does not explain more than 40% of the variance and it therefore needs to be improved.

Limitations of technology acceptance model: One of the limitations of TAM is that perceived ease of use is not a good indicator when predicting actual technology use (Turner *et al*., 2010). Behavioural intention predicts actual technology use better. They further caution that, researchers and users of TAM need to be aware that they may be measuring perceived use and not actual system usage. They further argue that TAM could be appropriate while evaluating pre-prototype systems where the aim is to measure the perceived ease of use of the pre-prototype. Another concern regarding perceived ease of use is that little is known about its determinants and little been done to understand it (Venkatesh, 2000).

Another limitation identified by scholars is that despite the fact that TAM is predictive it does not

provide sufficient information regarding system design attributes that could improve user acceptance for new systems (Mathieson, 1991). This fact was also acknowledged by its own researcher who admitted that TAM does not provide enough information regarding a system's acceptance in ways that guide development but only suggests that system characteristics impact on ease of use and usefulness perceptions (Venkatesh and Davis, 1996).

Social influence is another aspect not catered for by the TAM Model (Davis *et al*., 1989). Davis *et al*. (1989) also noted that there was need to conduct further research in order to comprehend the nature of social influences in a better way and to examine conditions and mechanisms governing the impact of social influences on usage behaviour.

TAM was developed and tested in developed countries and may not exactly fit in an African setup because of the cultural difference unless it is modified (Anandarajan *et al*., 2002). TAM has been tested in the context of a developing country in the adoption of web based learning technologies. That study established that perceived usefulness might not be a predictor of adoption and established that perceived ease of use plays a more significant role (Brown, 2002).

This study established that the TAM Model would need more constructs to make the model more appropriate for predicting OSS adoption behaviour in developing countries. This conclusion is guided by the fact that TAM does not take into account the effect of social influence on usage behaviour and does not provide sufficient information regarding system design attributes that could improve user acceptance for new systems as observed by Mathieson (1991). Social influence plays a significant role in the adoption of technologies and cannot be ignored. Perceived ease of use is used in TAM but according to Turner *et al*. (2010) it is not a good indicator compared to behavioural intention while predicting actual usage of a system making TAM unsuitable as an OSS adoption prediction model.

Theory of Planned Behaviour (TPB): TPB is an extension of TRA which was developed with the aim of addressing the weaknesses of TRA (Ajzen, 1991). One of the major weaknesses of TRA is that it deals with only those behaviours that are under a person's volitional control (Ajzen, 1991). As a result, actions that are at least partially determined by factors beyond individual's voluntary control fall outside the boundary conditions established for the model.

A principal factor in TPB is the individual's intention to accomplish a particular behaviour just as in TRA (Ajzen, 1991). The difference between TPB and TRA is the inclusion of perceived behavioural control plays an important part in the theory of planned behaviour. Ajzen (1991), defines perceived behavioural control as people's perception of the ease or difficulty of performing the behaviour of interest. The supporting theory of behavioural control was provided by the researcher carried out by Bandura *et al*. (1961) which established that people's behaviour is highly influenced by their confidence in their ability to perform it (Bandura *et al*., 1977; Bandura *et al*., 1980).

TPB "places the construct of self-efficacy belief or perceived behavioral control within a more general framework of the relations among beliefs, attitudes, intentions and behavior" (Ajzen, 1991). Hypothetically behavioural achievement can be predicted using perceived behavioural control together with behavioural intention (Ajzen, 1991). TPB assumes that performance of a behaviour is a combined function of intentions and perceived behavioural control. Intentions and perceptions of control have to be evaluated in relation to the specific behaviour under study and the stated context must be the same as that in which the behaviour is to happen (Ajzen, 1991). A second condition in behavioural prediction is that perceived behavioural control must remain stable in the interval between their assessment and observation of the behaviour.

As mentioned earlier, the supporting theory of behavioural control was provided by the researcher carried out by Bandura *et al*. (1980) as an extension of TRA. The studies conducted by other researchers revealed that actions performed by an individual are partially determined by factors beyond the individual's voluntary control. Although, TBP largely borrowed from TRA the additions were informed by researcher of Bandura *et al*. (1977) and Bandura (1982) which provided support for the relationship between perceived control and behavioural performance.

In the development of TPB, Ajzen (1991) further argued that past performance of behaviour influences present behaviour. The present behaviour is free of behavioural intentions, attitudes or subjective norms (Bandura, 1982; Bentler and Speckart, 1979). This argument was founded on the study conducted by Bentler and Speckart (1979) that revealed that intentions could be directly influenced by factors other than attitudes and subjective norms.

Application of TPB in information systems research: TPB has been commonly used in past studies in the issues of human behaviour and psychology (Ahmad *et al*., 2016; Barnett and Presley, 2004). Apart

from human behaviour related studies the model has also been used to predict intentions and behaviour in other domains (Armitage and Corner, 2001). A comparative study of TAM and TPB established that, although, TAM predicts actual usage better, TPB provides a better understanding of the determinants of behavioural intentions (Lin, 2007).

TPB has been applied to investigate consumer acceptance of online video and television services in France (Truong, 2009). The study established that TPB is an appropriate model for predicting user acceptance of online video services. The study further noted that the perceived behavioural control construct is more significant in predicting acceptance of the online video services (Truong, 2009).

A cross-cultural study investigating the drivers of ecommerce that was conducted in both China and the US employed TPB (Pavlou and Chai, 2002). The study related online transaction intentions with attitude, behavioural control and subjective norm. In this study cultural dimensions such as individualism/collectivism and power distance were included as moderators of the effect of TPB variables on online consumer behavior (Pavlou and Chai, 2002).

Another study that sought to predict the determinants of online auction adoption by consumers in China employed TPB but included DoI constructs (Quaddus *et al*., 2005). The study indicated that trust, behavioural control and subject norm, plays an important role on the purchasing intention through on-line auction. The results indicated that personal innovativeness and attitude do not play an important role on the buying intention (Quaddus *et al*., 2005).

TPB has been applied in Africa to investigate the factors influencing IT worker's green computing intention in a study that was conducted in South Africa (Buisson and Naidoo, 2014). The study included environmental concern antecedent of attitude towards green computing and extended subjective norm to include social influence and media influence. The study established that social influence, media influence, perceived behavioural control and environmental concern positively influence the intention to practice green computing (Buisson and Naidoo, 2014).

A number of studies conducted in African countries seeking to establish the factors of IS adoption have incorporated the constructs of models such as TAM and TPB in order to increase the prediction power of TPB. In Nigeria, a study conducted to investigate the factors influencing the adoption of e-Health services employed TPB integrated with TAM and DoI constructs (Okuboyejo and Ochiotu, 2006). Another study that sought to establish the factors inhibiting consumer adoption of internet banking in Kenya integrated TPB with TAM constructs (Karungu, 2014).

Limitations of TPB: TPB is difficult to apply across different user contexts because it requires a pilot study to be carried out to identify relevant outcomes, referent groups and control variables in every context in which it is used (Mathieson, 1991). A study that sought to investigate the internet and web technologies adoption behaviour conducted a pilot study in the US before conducting the main study (Barnett and Presley, 2004). Application of TPB is complex if different user clusters concentrate on different outcomes from use of the same system (Mathieson, 1991). For example, university students using an open source computer based learning system could be interested in improving their grades while their tutor's interest is in saving class time. A similar conclusion was drawn by Taylor and Todd (1995) who concluded that TPB is difficult to operationalize because the belief sets especially, those relating to attitude are peculiar to each context.

Another limitation identified by Mathieson (1991) is that some TPB items require an explicit behavioural alternative to make them as specific as possible. For example potential users of an open source word processing software might be asked to respond to the following question "Using Microsoft word instead of open office writer saves me time while writing a thesis report (Agree/disagree)". This approach may not apply to all individuals because in our example not all users might have used Open office writer and may not yield useful feedback.

This study established that the TPB Model would need to be modified to make the model more suitable for predicting adoption of free Desktop OSS in Africa. This is because OSS is used by different users in different contexts to perform different tasks. In order to apply TPB it means that the researcher would need to perform a pilot study for each scenario in order to identify relevant outcomes, referent groups and control variables in every context. The researcher would also need to identify the different OS product alternatives available in the market for performing a certain tasks. This will not only be difficult to achieve but it will consume a lot of time.

Model of PC Utilisation (MPCU): The MPCU Model was based on a subset by Triandi (1971, 1980)'s theory of attitudes and behaviour (Thompson *et al*., 1991). One of the main bases of the theory of attitudes and behaviour is that social factors and observed consequences affect behavioural intentions which consequently influence

behaviour (Triandis, 1980). He further states that habits are both direct and indirect causes of behaviour and accepts that even when intentions are high behaviour may not occur if the conditions are unfavourable.

While developing their model, Thompson *et al.* (1991) tested a subset by Triandi's (1980) theory in relation to PC use where they specifically, examined the direct effects of social factors, affect, perceived consequences and facilitating conditions on behaviour as discussed below.

Social factors: As argued by Triandis (1980) this is the person's adoption of the reference group's subjective culture, alongside particular interpersonal agreements that the person has made with others in particular situations. Behaviour is influenced by social norms which are dependent on messages received from others and reflect what individuals think they should do in particular situations (Triandis, 1971). According to Thompson *et al.* (1991), there is empirical support for the relationship between social norms and behaviour in many studies.

Affect: It is defined by Triandis (1980) as "the feelings of joy, elation or pleasure or depression, disgust, displeasure or hate associated by an individual with a particular Act".

Perceived consequences: According to Triandis (1980), each act performed by an individual is perceived as having potential consequences that have an associated value and a probability that the consequence will occur. He argues that perceived consequences could have many dimensions and he cites the example of enhanced job satisfaction and job flexibility as two different constructs that could be referred to as perceived consequences.

Facilitating conditions: Triandis (1980) defines facilitating conditions as objective factors within the environment that are generally agreed by observers as making an act easier to perform. According to Thompson *et al.* (1991) user support and training are facilitating conditions on the context of PC use.

Other factors tested in their study are job-fit, long term consequence of use and habit which formed part of the hypothesis in their study. Using a Likert-type scale questionnaire, the study was conducted in a large multinational manufacturing organization where the target population was knowledge workers who used Personal Computers (PCs) in their jobs.

After collecting the data Thompson *et al.* (1991) used the Partial Least Squares (PLS) analysis to test the research hypothesis. The results showed that the hypothesis test provided a moderate support for the MPCU. The results established that "social factors, complexity, job fit and long-term consequences had significant effects on PC use" (Thompson *et al.*, 1991).

Application of MPCU in information systems research: MPCU differs from TRA because it differentiates between affective and cognitive components of attitude (Sharma and Mishra, 2014). This study found very limited literature on studies that solely applied MPCU as a model to predict adoption of information systems. MPCU is not one of the commonly used technology acceptance model in the area of information systems (Samaradiwakara and Gunawardena, 2014; Al-Mamary *et al.*, 2016).

PC utilisation among knowledge workers in Saudi Arabia has been analysed using some constructs of MPCU (Al-Khaldi and Wallace, 1999). The study by Al-Khaldi and Wallace (1999) also borrowed from Triandis (1971) theory which proposes that behaviour is controlled by attitudes, habits, social norms and expected consequences of behaviour. The study used the constructs: social factors, affect, cognitive factors, facilitating conditions, perceived complexity, long-term consequences experience, perceived job fit, training and degree of PC access. The study established that personal characteristics such as PC experience, individual attitudes, facilitating conditions such as PC access and social factors determine PC utilization (Al-Khaldi and Wallace, 1999).

MPCU has been applied to predict internet/World Wide Web (WWW) usage at work in a study conducted in China (Cheung *et al.*, 2000). The intention construct was dropped because the study intended to predict the actual usage behaviour and not the intention. Their study investigated the direct effects of affect, perceived consequences and social factors on current usage behaviour (Cheung *et al.*, 2000). The study confirmed that social factors and facilitating conditions are the two most significant factors affecting internet/WWW usage. Perceived near-term consequences and perceived complexity were also found to be significant (Cheung *et al.*, 2000).

In a comparison of the popular technology acceptance models job-fit is the only construct of MPCU that was found to be significant in both mandatory and voluntary settings over time (Venkatesh *et al.*, 2003). The social factors of the MPCU Model were found to be significant only in mandatory settings.

Limitations of Model of PC Utilisation: The model of PC utilisation provides a test by Triandis (1980) theory in a PC use environment. In their empirical test of the theory

Thompson *et al.* (1991) the test relied on the perceptions of respondents and was not backed by actual usage statistics to confirm or disconfirm the perceptions of the respondents. A study that applied the model dropped the intention construct because the construct does not predict the actual usage (Cheung *et al.*, 2000).

MPCU is very specific and limiting as it is generally designed to apply in PC utilisation setups and for the model to perform well in other setups, additional constructs need to be included. This study has also established the Model of PC utilisation ignores the cost factor which is important in the adoption of OSS products. OSS products provide a solution to the user that is supposed to lead to cost savings in adopting the OSS technology as opposed to the proprietary products. According to the Rogers (1995) diffusion of innovations theory lower priced innovations are likely to be adopted faster than higher priced ones.

Motivational Model (MM): The model was developed as a result of a study that was conducted to establish and understand what motivates people to accept or reject computers in the workplace (Davis *et al.*, 1992). Their study intended to compare the influence of perceived usefulness and enjoyment on intentions to use computers in the workplace. From the literature they reviewed they established that there are two broad classes of motivation to perform an activity which are extrinsic motivation and intrinsic motivation.

Davis *et al.* (1992), further established from literature that extrinsic motivation is the performance of a task because it is perceived to be helpful in accomplishing valued results that are different from the task itself such as increased job performance, remuneration or promotions (Davis *et al.*, 1992). They further defined intrinsic motivation as the "performance of an activity for no apparent reinforcement other than the process of performing the activity per se" (Davis *et al.*, 1992).

Davis *et al.* (1992), conducted a study at a midwestern university in the US, regarding the use of word processing software in two public laboratories. In this study 200 MBA students participated by filling in a questionnaire where perceived usefulness was measured using four seven point likely/unlikely items. The majority of the participants had little or no experience with personal computers and word processing programs in general (Davis *et al.*, 1992). A second study was conducted by Davis *et al.* (1992) at an eastern university in the US which involved forty MBA evening students who participated in a 2 h laboratory session. In this study the participants had a range of experience from limited to extensive although they were not familiar with the two programs used in the study. After conducting the study the results established that "people's intentions to use computers in the workplace are mainly influenced by their perceptions of how useful the computers are in improving their job performance" (Davis *et al.*, 1992). The study further revealed that the degree of enjoyment employees experience in using computers is a secondary factor that influences the use of computers in the workplace.

Application of MM in information systems research: MM is regarded as a popular technology adoption model (Venkatesh *et al.*, 2003). Many studies have also integrated MM's popular constructs, extrinsic motivation and intrinsic motivation into other models such as TAM. This study found very limited literature on studies that solely employed MM as a model to predict adoption of Information systems.

A study that sought to establish the significance of extrinsic motivation and intrinsic motivation on internet usage incorporated both perceived ease of use and perceived usefulness into their research model (Teo *et al.*, 1999). The study revealed that individuals use the internet because they perceive that it is useful in helping them accomplish their duties and it is also easy to use. The study which was conducted in Singapore revealed that extrinsic motivation is usually stronger than intrinsic motivation (Teo *et al.*, 1999).

The construct intrinsic motivation of MM was integrated with TAM in a study aimed at understanding how user's perceptions form and change over time (Venkatesh, 2000). The study which was conducted in three different organisations established that intrinsic motivation (computer playfulness) contributed to the perceived ease of use of a new system.

A study conducted by Abduljalil and Zainuddin (2015) which sought to establish the role of intrinsic and extrinsic motivation towards adoption of accounting information systems in Libyan SMEs employed MM. This study incorporated IT innovativeness, IT knowledge and IT trust as additional constructs. The study established that intrinsic and extrinsic motivation contributes to the user's intention to adopt information systems.

Another study conducted in two different countries (China and Canada) investigating the role of intrinsic motivation in the adoption of e-Learning technologies by learners applied intrinsic motivation construct of MM and integrated it with TAM constructs (Saade *et al.*, 2009). The study established that intrinsic motivation plays a limited role in influencing adoption of e-Learning among the Canadian students while in China, the role played by intrinsic motivation is significant. Extrinsic motivation and intrinsic motivation were integrated with TAM in a study

that sought to identify the determinants of usage intentions in social network games (Chang and Chin, 2011). The study which was conducted in Taiwan established that both extrinsic motivation and intrinsic motivation contribute to the intention to use social networking games.

The studies reviewed above reveal that in many studies, MM has been used to complement TAM in understanding information systems user's behaviour. This is a demonstration that MM as a model has limited constructs and has to be integrated with other models such as TAM to make it useful in research. This study notes that the extrinsic motivation and intrinsic motivation constructs have been found to be useful determinants in prediction of intention to adopt a technology.

Limitations of motivational model: One of the limitations noted by Davis *et al*. (1992) is that the theory has limited constructs lowering the model's prediction power. They suggest that in the future there is a need to examine the role of additional constructs. They further point out that there is a need to establish how widely their findings generalise to other systems and user populations.

This study notes that the motivational model ignores a number of factors that are instrumental in the adoption of computers in the workplace. The motivational model only identifies perception of usefulness and enjoyment as the main factors contributing to adoption of computers in the workplace. The model ignores social influence, facilitating conditions (such as user training and user support) which are important computer technology adoption determinants as noted by Venkatesh *et al*., (2003).

The MM is not a strong model for predicting adoption of OSS Software in developing countries such as in Africa unless additional constructs such as social influence are added to make it more appropriate in an African set up.

Combined TAM and TBP: The research that led to the combination of TAM and TBP was grounded from the models from social psychology such as the TRA and TBP (Taylor and Todd, 1995). The study employed TAM which according to them has developed as an authoritative and parsimonious way to characterise the antecedents of computer systems usage. They, however noted that TAM had not been tested with actual measures of usage behaviour but had been applied to measure usage intention or self-reported measures of usage which in most cases are collected with the measurement of beliefs, attitudes and intention. The study by Taylor and Todd (1995), compared TAM and TPB Models as well as an integrated version of TAM and TPB. The study noted that, TAM's measures of ease of use and usefulness were based on well developed, refined and validated measures (Davis, 1989). The study also noted that, TRA and TPB belief measures were not ideal because they are based on a salient belief elicitation measure which makes a scale idiosyncratic to a particular setting (Taylor and Todd, 1995).

Combined TAM and TPB Model was developed in order to address the weaknesses of the two models. The resultant model recommended a set of stable, decomposed structures where attitudinal, normative and control beliefs were decomposed into multi-dimensional belief constructs (Taylor and Todd, 1995). According to them, the reason for decomposing these constructs was to provide a stable set of belief constructs which can be applied across a variety of settings and help in pointing to specific factors that could influence adoption and usage. They finally identified attitude toward behaviour, subjective norm, perceived behavioural control and perceived usefulness as the core constructs of their model. Taylor and Todd (1995), tested the three models (TAM, TPB and Combined TAM and TPB) in a Computing Resource Centre (CRC) setup where business school students use different computer applications.

According to Taylor and Todd (1995), the decomposed theory of planned behaviour (Combined TAM and TPB) was found to be better than TAM and TPB as it provides a more comprehensive understanding of usage behaviour and intention. They further argued that TAM is applicable in occasions where the only objective is to predict usage. They concluded that the combined TAM and TPB Model is more useful to researchers and IT managers who have an interest in studying system implementation.

Application of TAM and TPB in information systems research: A study investigating the factors affecting the adoption of electronic banking that was conducted in Jordan combined both TAM and TPB (Al-Smadi, 2012). The study added five cultural dimensions and perceived risk into the constructs of TAM and TPB. The study revealed that perceived ease of use and perceived usefulness contributes positively to the customer's attitude towards electronic banking services (Al-Smadi, 2012). The study also noted that among the cultural dimensions (power distance, uncertainty avoidance, individualism vs. collectivism, masculinity vs. femininity, long term vs. short term orientation) uncertainty avoidance has a positive and significant impact on perceived ease of use and perceived usefulness (Al-Smadi, 2012). Combined TAM and TPB as

a model has been applied in investigating the factors contributing to internet purchasing (Sentosa and Mat, 2012). The study sought to examine the relationships between perceived usefulness, attitude, perceived behaviour control, perceived ease of use and subjective norm toward intention and internet purchasing behaviour. The combined TAM and TPB was found to be better in explaining the internet purchasing behaviour than TAM and TPB individually (Sentosa and Mat, 2012).

Limitations of combined TAM and TPB: The combined TAM and TBP has attracted limited studies either validating it or otherwise. A literature search by the researcher established that at this time are no existing studies invalidating the model. In the view of the desktop OSS adoption, this study established that combined TAM and TBP may not be the most ideal model in the prediction of use behaviour because the combined TAM and TBP does not include some important factors of adoption such as prior experience in using a similar technology and the social economic status of the individual. In the OSS adoption scenario, there is already a proprietary product which in this case is an alternative technology that is not only a competitor but provides an alternative at a price. Although prior experience can be seen as a facilitating condition in the combined TAM and TBP Model, the researcher feels that it should be treated as a separate factor.

Unified Theory of Acceptance and Use of Technology (UTAUT): UTAUT was developed with the aim of harmonising several models that have been used in the past to predict and explain technology adoption. The unified theory does this by integrating elements across eight models namely, Theory of Reasoned Action, Technology Acceptance Model, Motivation Model, Theory of Planned Behaviour, Combined TAM and TBC, Model of PC Utilisation, diffusion of innovations and Social Cognitive theory (Venkatesh *et al*., 2003).

The model was developed by first assessing the similarities and differences across the eight common models (Venkatesh *et al*., 2003). They later conducted a longitudinal validation and comparison of the eight models using data from individuals at four organisations where a new technology was being introduced in the workplace. A work place is regarded as a mandatory setting not a voluntary setting (Venkatesh *et al*., 2012). The data collection was scheduled to take place in concurrence with a training program connected with introduction of the new technology. According to Venkatesh *et al*. (2003), a questionnaire which was already pretested was administered at three different points in time at post training, one month after implementation and three months after implementation. The questionnaire contained items measuring constructs from all the eight models using a seven point scale with one being the negative end of the scale and seven being the positive end of the scale. The results revealed that the models "explained individual acceptance with variance in intention explained ranging from 17-42%" (Venkatesh *et al*., 2003).

After conducting the empirical tests they concluded that seven constructs seemed to be significant direct determinants of either intention to use a technology or actual usage in one or more of the individual models under study. From the seven constructs they considered four as direct determinants of user acceptance and usage behaviour, namely, performance expectancy, effort expectancy, social influence and facilitating conditions. They further theorised that attitude towards using a technology, self-efficacy and anxiety are not direct determinants of intention.

Having identified the constructs of their proposed model as well as their moderators by Venkatesh *et al*. (2003), empirically validated the model where all constructs apart from use were modelled using reflective indicators. Their results proved that UTAUT was a better predictor of usage intention than any of the eight original models as well as their extensions.

Application of UTAUT in information systems research: In the past UTAUT has played an important role in technology acceptance research and has provided a solid theoretical base to explain why users accept or reject a technology (Samaradiwakara and Gunawardena, 2014). UTAUT has been used in many countries such as the USA, China, Taiwan, Malaysia, Australia, India, Belgum and Tanzania although, the majority of the studies that have employed UTAUT have been conducted in the USA (Williams *et al*., 2015). Although, the theory has been cited numerous times, the actual studies that have utilised the theory in research are significantly less (Dwivedi *et al*., 2011). UTAUT has been tested and improved by researchers utilizing existing models in conjunction with UTAUT and by introducing constructs and exploring different relationships between its constituent constructs in various contexts (Williams *et al*., 2015).

UTAUT has been used in the US, to study the adoption of established and emerging information technology in higher education classrooms (Lewis *et al*., 2013). The study established that, the most essential antecedents of intention to use IT "are performance expectancy, effort expectancy, social influence and habit

with more complex effects when gender is added as an interaction term" (Lewis *et al*., 2013). The study recommended a cross cultural study of technology adoption technologies using UTAUT in order to understand the implications of cultural variations to technology adoption.

A modified UTAUT Model has been used in a study that investigated the factors that influence academics to use m-banking and in particular SMS-based mobile banking in Nigeria (Olasina, 2015). The modified model used the constructs: social influence, perceived usefulness, perceived ease of use, behavioural intention, user expectation, ICT skills, perceived value, type of bank, gender and customer service (Olasina, 2015). All the factors were found to influence the use of m-banking in Nigeria.

Another study conducted in Kenya investigating the factors influencing use of mobile phones as a tool in ecommerce employed a modified UTAUT Model (Wamuyu and Maharaj, 2011). The study established that the factors usage and appropriateness directly and substantially affected organizational performance while user acceptance and appropriateness were significant determinants of usage (Wamuyu and Maharaj, 2011). In the same study, only performance risks was found to be insignificant from the hypothesised barriers of adoption, security risks, affordability and performance risks.

Apart from the few studies cited above, UTAUT has been applied in various areas of research such as the internet, hospital information systems, web sites, mobile technology and tax payment systems among others (Williams *et al*., 2015). A study that reviewed 43 research reports, noted that 22 of the studies reviewed had introduced external constructs that are not in the original UTAUT Model (Dwivedi *et al*., 2011). Some of the common constructs by Dwivedi *et al*. (2011) noted were introduced in the studies are anxiety, attitude, self-efficacy, trust, PEOU, PU, perceived credibility and perceived risk.

Limitations of UTAUT: In relation to the prediction of OSS adoption UTAUT misses one important factor which is cost which is an important consideration when predicting adoption in voluntary use settings (Lewis *et al*., 2013). This omission was noted by some of its own researchers Venkatesh *et al*. (2012) after noting that the amount of money to be spent in relation to the perceived benefits is an important factor to be considered while adopting a technology especially in voluntary settings. Cost is a major determinant in the adoption of a technology and can also be seen as a facilitating condition or a constraining condition (Brown and Venkatesh, 2005). This study notes that the UTAUT Model does not put much weight on usability of the product under study. In studies pertaining to a software product, the Human Computer Interface (HCI) design of the product is a very important aspect which determines the usability of the software product under study.

Another limitation of UTAUT which has been noted and reported in many studies is its applicability across country, culture organization, department, agency, person or age group (Williams *et al*., 2015).

This study concludes that this model would need some additional constructs to deal with cost and usability in order to make it more adequate as a predictor for explaining adoption of free OSS products in Africa.

Extended Unified Theory of Acceptance and Use of Technology (EUTAUT): After UTAUT was developed it gained popularity and was used in many studies in some cases wholly and in others partially (Venkatesh *et al*., 2012). The original model had been extended in a number of studies which informed by Venkatesh *et al*. (2012) extension of the original model. This was done in order to improve the original model and overcome its limitations as well as to identify the salient factors that would apply to a consumer technology use context (Venkatesh *et al*., 2012). The original UTAUT was extended and applied in the areas of collaborative technology and health information systems. The UTAUT Model was also applied in new populations and even new cultural settings such as in China and India.

The original UTAUT was extended by identifying additional key constructs and relationships with the aim of tailoring it to a consumer use context (Venkatesh *et al*., 2012). The new constructs supported by other earlier empirical studies are hedonic motivation, price and habit. They dropped voluntariness from the original UTAUT as a moderator and added a link between facilitating conditions and behavioural intention.

Hedonic motivation is defined as the pleasure or fun resulting from using a technology (Brown and Venkatesh, 2005). The hedonic motivation construct was supported by empirical studies carried out by Brown and Venkatesh (2005), among others which revealed that hedonic motivation was an important determinant of technology acceptance and use. They further hypothesised that "the cost and pricing structure may have a significant impact on consumer's technology use" (Venkatesh *et al*., 2012).

According to Venkatesh *et al*. (2012), experience as conceptualised in prior research "reflects an opportunity

Table 1: A comparison of the constructs in the common technology adoption models

Construct	Constructs with a similar meaning	Models/theories using	Moderators
Performance expectancy	Perceived usefulness, extrinsic motivation, job fit, relative advantage	TAM, MPCU, DoI, SCT, EUTAUT, UTAUT	Age, gender
Effort expectancy	Perceived ease of use, complexity, ease of use	TAM, MPCU, DoI, UTAUT, EUTAUT	Age and gender
Cost	Price value	E-UTAUT	Age and gender
Social influence	Social norms, social factors, image	TRA, MPCU, DoI, UTAUT, EUTAUT	Gender, age, voluntariness
Facilitating conditions	Compatibility	DoI, UTAUT, EUTAUT	Age, gender and experience
Hedonic motivation	Subjective norm	TPB, EUTAUT	Age, gender and experience
Behavioural intention		TRA, UTAUT, EUTAUT	
Habit		EUTAUT	Age, gender and experience

to use a target technology and is typically operationalized as the passage of time from the initial use of a technology by an individual". The empirical study undertaken to validate the proposed extended model was carried out in Hong Kong among users of mobile internet technology (Venkatesh *et al*., 2012). In this scenario the decision to use a mobile device to exchange messages, pictures and emails etc. in a consumer context is a voluntary decision. The measurement was done using a "seven-point Likert scale with the anchors being strongly disagree and strongly agree" (Venkatesh *et al*., 2012). The data collection was done through a two stage online survey with 4,127 and 2,220 valid respondents, respectively.

Data analysis was done using partial least squares to test the model as it was found appropriate because of the many interaction terms (Venkatesh *et al*., 2012). Their results revealed that age and gender moderated the facilitating conditions effect on behavioural intention. The study also revealed that "age, gender and experience will moderate the effect of hedonic motivation on behavioural intention" (Venkatesh *et al*., 2012) as well as price value on behavioural intention. The study further established that the effects of behavioural intention will deteriorate with increasing experience.

EUTAUT has the eight constructs identified from the different common technology adoption models. The eight constructs of EUTAUT are performance expectancy, effort expectancy, cost/price value, social influence and facilitating conditions, hedonic motivation, Behavioural intention and habit. EUTAUT was developed with the aim of predicting voluntary technology adoption and was tested in the mobile internet consumer context (Venkatesh *et al*., 2012). EUTAUT synthesised all its major predecessors and accommodated all the constructs although some have different names as demonstrated by Table 1 (Gooup *et al*., 2012).

Application of EUTAUT in information systems research: A study conducted by Raman and Don (2013) that aimed at establishing the relationships between the constructs that influence preservice teacher's adoption of moodle (a FOSS) in their learning process was conducted in Malaysia. The study used EUTAUT Model to examine the factors that contribute to the adoption of moodle. The findings were consistent with those of Venkatesh *et al*. (2012) EUTAUT apart from the habit construct which was not significant because in this context the respondents were using moodle for academic purposes only (Raman and Don, 2013). Raman and Don (2013) concluded that the model was less suitable in educational settings and recommended more variables such as security and time of access to be included in order to make the model more appropriate for the context.

EUTAUT has been tested in Turkey in the context of educational technology adoption. The study recommended the incorporation of cultural dimensions as a construct in order to make it more predictive across different cultures (Gooup *et al*., 2012). The study further noted that including computer literacy as a variable of the EUTAUT Model is likely to become the strongest independent variable. Gooup *et al*. (2012) note that although EUTAUT has included facilitating conditions which encompass computer anxiety, EUTAUT can be more explicative if computer anxiety can be included as a construct on its own.

Another study that aimed at validating EUTAUT was conducted in Spain that aimed at establishing the determinants of consumer purchase of website airline tickets (Escobar and Trujillo, 2013). The study established that the main determinants of online purchase intention are in order of significance, habit, price saving, performance expectancy and facilitating conditions (Escobar and Trujillo, 2013). The study further noted that there was no "significant impact of effort expectancy on the online purchase intention, social influence from referents; and hedonic motivation to use the website" (Escobar and Trujillo, 2013).

EUTAUT has also been tested in a study that was conducted in a Spanish public university which aimed at identifying the factors that contribute to the adoption of social media technologies in learning (Escobar *et al*., 2014). The study established that, facilitating conditions, hedonic motivation, effort expectancy, social influence, performance expectancy and habit were found to be useful in predicting student's intention to adopt social

Table 2: Summarises the weaknesses of the different models that were identified after the review

Models	Limitations
TRA	The theory was developed to deal with behaviours (e.g., buying a car) and not outcomes or events that result from behaviours
	The model deals with only those behaviours that are under a person's volitional control
	The model is not suitable to study goals for which attainment involves a degree of uncertainty and in cases where a person is presented with several choices
TAM	Perceived ease of use is not a good indicator when predicting actual technology use
	Little is known about perceived ease of use and its determinants
	Although, TAM is predictive it does not provide sufficient information regarding system design attributes that could improve user acceptance for new systems
	Social influence factor is not catered for by the TAM Model
MM	The theory has limited constructs
	The model ignores social influence and facilitating conditions (such as user training and user support) which are important computer technology adoption determinants
TPB	TPB is difficult to apply across different user contexts because it requires a pilot study to be carried out to identify relevant outcomes, referent groups and control variables in every context in which it is used
	Some TPB items require an explicit behavioural alternative to make them as specific as possible
Combined TAM and TBP	The model does not include some important factors of adoption such as prior experience in using a similar technology and the social economic status of the individual
MPCU	The model ignores the cost factor which is important in the adoption of OSS products
IDT	Experience in using a technology has been ignored as a factor that contributes to the adoption of a technology in the model
	IDT theory was developed purposely for new technological innovations
SCT	The model does not have constructs relating to the attributes of the IS product being investigated such as usability but rather concentrates on social influence and other social aspects that influence an individual's behaviour
	The model was not originally developed to study technology adoption
UTAUT	The cost factor as a determinant in the adoption of a technology has been ignored in the model
	The model does not put much weight on usability of the product which in relation to a software product is very much dependent on the Human Computer Interface (HCI) design of the product
EUTAUT	The model bundles some important constructs into one construct making it difficult to measure the impact of the individual factors influencing the uptake of desktop OSS adoption in Africa

media technologies in learning. In the context of mobile money payment adoption in the UK, EUTAUT was found to be lacking perceived risk and trust constructs that were considered important in this context (Slade *et al*., 2013). The addition of the two constructs in the study resulted in EUTAUT becoming more appropriate in this scenario. A similar study conducted in Saudi Arabia had consistent findings with the UK study because the two constructs (trust and risk) were incorporated into EUTAUT in order to make it more predictive in the mobile technologies consumer adoption scenario (Baabdullah *et al*., 2014).

A study conducted in Tanzania that employed EUTAUT revealed that apart from performance expectancy all other constructs in EUTAUT were significant in determining the adoption of multimedia enhanced content in secondary schools (Mtebe *et al*., 2016). Their study noted that EUTAUT needed to be improved by adding constructs such as information quality, attitude and awareness in order to make the model more predictive in this situation.

Limitations of EUTAUT: Many studies have been conducted to test or validate EUTAUT despite the fact that it is a relatively recent extension. The model also currently seems to be one of the latest technology acceptance models in the information systems domain which is likely to attract a lot of attention from researchers just like its precursor UTAUT. This study however, notes that other studies that have tested the model have had to incorporate extra constructs to make the model more predictive. For example the study that used the model to predict mobile money payments added trust and risk constructs. It is not clear how the model would perform if applied in Africa to predict the adoption of free desktop OSS.

This study established that the EUTAUT Model bundles some important constructs into one construct making it impossible to measure the impact of the individual factors influencing the uptake of free OSS adoption in Africa. Facilitating conditions includes too many items in one and in this case user training, usability and compatibility with other competing applications can be termed as facilitating conditions. This study established that it is important to measure the impact of these individual factors/constructs in the adoption of free OSS products and even determine their moderating variables.

All the models discussed above were found to be lacking some aspects that are useful in predicting desktop OSS adoption in developing countries such as in Africa. It is however important to note that the EUTAUT Model has majority of the constructs that would be useful in predicting free desktop OSS adoption in Africa (Table 2).

RESULTS AND DISCUSSION

Different technology adoption models have been reviewed with the aim of establishing the appropriateness

of the models in the African setup. The limitations of each of the model have been discussed based on the existing literature. The appropriateness of each of the model in predicting use behaviour in an African setup is discussed in this study.

TRA: TRA is not an appropriate theory that can be useful in explaining technology adoption in Africa because it deals with behaviours that are under a person's volitional control. Adoption of desktop OSS in Africa goes beyond an individual because there are external factors such as the cost and social influence. The theory is also not appropriate because it cannot be applied in scenarios where a number of closely related options are availed to an individual (Fishbein and Ajzen, 1975). In the case of desktop OSS in Africa, there are several software options available to a computer user. For example, in the case where a user wishes to use a spread sheet, there are several options including the desktop OSS product which can be able to perform the same task. Due to the before highlighted weaknesses of the model this study concludes that the TRA theory needs additional constructs in order to better explain the usage behaviour of computer systems in general and in particular adoption of desktop OSS Software.

TAM: This study concludes that TAM is lack some constructs that could be useful in predicting usage and adoption behaviour of desktop OSS products in Africa. This conclusion is guided by the fact that TAM does not put into account the effect of social influence on usage behaviour and does not provide sufficient information regarding system design attributes that could improve user acceptance for new systems as observed by Mathieson (1991). Social influence plays a significant role in the adoption of technologies and cannot be ignored. Perceived ease of use is used in TAM but according to Turner *et al.* (2010) it is not a good indicator compared to behavioural intention while predicting actual usage of a system making TAM unsuitable as a desktop OSS adoption prediction model.

MM: This study notes that the MM ignores a number of factors that are instrumental in the adoption of computers in the workplace. MM only identifies perception of usefulness and enjoyment as the main factors contributing to adoption of computers in the workplace. The model ignores social influence, facilitating conditions (such as user training and user support) which are important computer technology adoption determinants as noted by Venkatesh *et al.* (2003). User training and user support are important determinants in the adoption of a software product by individual users in an African setup.

The study concludes that the model would need to be enhanced in order to make it more appropriate for predicting adoption of desktop OSS Software in developing countries such as in Africa.

TPB: In order to apply TPB, a pilot study needs to be conducted first and its application is complex especially if different user clusters concentrate on different outcomes from the same system (Mathieson, 1991). Desktop OSS is used by different African users in different contexts to perform different tasks. In order to apply TPB it means that the researcher would need to perform a pilot study for each scenario in order to identify relevant outcomes, referent groups and control variables in every context. The researcher would also need to identify the different software product alternatives available in the market for performing a certain task. This will not only be difficult to achieve but it will consume a lot of time. This study concludes that TPB would need to be adjusted in order to make it more appropriate in predicting desktop OSS adoption in an African setup.

Combined TAM and TBP: The combined TAM and TBP does not include some important factors of adoption such as prior experience in using a similar technology and the social economic status of the individual. In the desktop OSS adoption scenario, there is already a proprietary product which in this case is an alternative technology that is not only a competitor but provides an alternative at a price. Although, prior experience can be seen as a facilitating condition in the combined TAM and TBP Model, the researcher feels that is should be treated separately as a factor. The above weaknesses lead to the conclusion that combined TAM and TBP would need to be enhanced in order to make it more appropriate in predicting desktop OSS adoption in Africa.

Model of PC utilisation: The researchers feel that the model of PC utilisation ignores the cost factor which is important in the adoption of desktop OSS products in an African setup. Desktop OSS products provide a solution to the user that is supposed to lead to cost savings in adopting the desktop OSS technology as opposed to the proprietary products. According to the Rogers (1995) lower priced innovations are likely to be adopted faster than higher priced ones. The study concludes that the model needs some additional constructs in order to make it more appropriate for predicting adoption of desktop OSS software in developing countries such as in Africa.

DoI: This study has established that IDT was developed purposely for predicting new technological innovations that have not been used before. In the case of desktop

OSS products, competing products are already in use which gives these users experience that is transferable when using a similar technology. IDT does not include prior experience as one of the determinants in adopting a technology. It is for the before reasons that this study concludes that IDT is not best suited for predicting desktop OSS adoption in developing countries such as Africa.

SCT: The model lacks appropriate constructs that are important in predicting technology adoption. The model lacks constructs such as the usability of the product being used and other facilitating conditions, for example, user training. This study has established that SCT is not appropriate for studying technology adoption in general, leave alone desktop OSS adoption in Africa. The researchers opine that the absence of important technology adoption constructs is due to the fact that the model was not originally developed to study technology adoption behaviour but to study other behaviour in the field of psychology. This study notes that SCT would need to be adjusted in order to make it more appropriate in predicting free desktop OSS adoption behaviour in developing countries.

UTAUT: This study notes that the UTAUT Model does not put much emphasis on usability of the product which in relation to a software product is very much dependent on the Human Computer Interface (HCI) design of the product. The omission of the cost factor of the technology being studied is also a major exclusion. Desktop OSS usability in an African setup is a major determinant of adoption as users shy away from software products that are complex to operate. This opinion is supported by an empirical study conducted by Kamau and Sanders which established that usability is a major determinant of desktop OSS adoption in Africa. This study notes that UTAUT would need to be adjusted in order to make it more appropriate in predicting free desktop OSS adoption behaviour in developing countries.

EUTAUT: The model was developed and tested in a non-African setup and it is not clear whether the results in an African setup would be consistent with those of other parts of the world. This study has established that technology acceptance models yield different results if tested in an African setup. This study has established that the model bundles some important constructs into one construct making it impossible to measure the impact of the individual factors influencing the uptake of free desktop OSS adoption in Africa. Facilitating conditions includes too many items in one and in this case user training, usability and compatibility with other competing applications can be termed as facilitating conditions. This study established that it is important to measure the impact of these individual factors/constructs in the adoption of OSS products and even determine their moderating variables in the African setup. It is however important to note that the EUTAUT Model has majority of the constructs that would be useful in predicting free desktop OSS adoption in Africa.

CONCLUSION

Based on the literature reviewed in this study, it is clear that none of the discussed technology adoption models fits in the African scenario without amending the constructs. The discussion before indicates that the discussed technology adoption models lack some areas in order to effectively predict desktop OSS adoption in Africa. A technology adoption model that is suitable to predict desktop OSS adoption in the African setup needs to be developed. The appropriate model should be appropriate in predicting individual usage behaviour of a software product in general. In addition the model should have constructs that take care of social economic factors as part of its salient constructs because majority of African countries have a different social economic and cultural setup.

The proposed model should have facilitating conditions such as user training, usability of the desktop OSS product, compatibility with other software products and social influence as part of its major constructs. Apart from the above constructs, the model should have prior experience and social economic status as they also play a significant role in determining whether a Desktop OSS product will be adopted in an African setup. The model should also have some moderating variables that are relevant to the African setup.

The developed model should be tested in the African setup in order to determine its appropriateness in predicting Desktop OSS and statistical tests performed to determine its level of validity.

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