

Performance of the Expanded Technology Acceptance Model in the Sub-Saharan African Context

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Abstract — The Technological Acceptance Model (TAM) and its extensions propounded by Fred Davis and other authors respectively, has broadly been applied on various technological novelties worldwide and has been very fruitful in predicting various technological acceptance behaviors in so many settings. On the basis that TAM may not hold true for some cultures including Sub-Saharan Africa, the expanded TAM for the Sub-Saharan African environment was developed. To ascertain expert opinion on it and assess its performance, this study examined the expert opinion and performance of the developed expanded TAM in the Sub-Saharan African context. Conducting telephone interview with six information systems and human computer interaction experts and administering questionnaire to 308 students in five public universities (using e-learning systems) in five Sub-Sahara Africa countries in the five Sub-Saharan Africa regions, data was collected and multiple regression analysis applied to compute variance (R²) of the independent and dependent constructs (PU, PEOU, PP, PB and BI respectively) in the developed expanded TAM model in the Sub-Saharan African context. Based on the validation of the model by the six experts, its constructs resulting variance were compared to the existing TAMs constructs variance. Results of the comparison showed that, the developed expanded TAM in the African context, outperformed the existing TAMs. Though this research was able to reach findings, it had a limitation of not being able to collect primary data on existing TAM models to compute their variance: future research in this area should work at overcoming this.

Keywords— Technology Acceptance, Expanded Technology Acceptance Model, Culture, Sub-Saharan Africa, Performance

I. INTRODUCTION

While some studies on technology acceptance concepts have applied the technology acceptance theories, models and frameworks, others have extended them. Among the studies that extended TAM in the African context include the study of [1], [2] and [3]. As discussed below, the said studies only considered data from isolated countries in Africa.

In [2] study on “service quality practices and customer satisfaction in taxi companies in Nairobi”, [2] used the

expectancy disconfirmation theory and applied a descriptive and inferential statistics to examine data in the study. Upon analyses of the service quality data and customer satisfaction data that the researcher collected from 40 managers and 120 customers in the Kenyan taxi industry, [2] concluded that customers are satisfied with taxi companies and thus loyal to taxi service providers.

In their work to identify “commonly used external constructs of TAM in e-learning adoption”, [1] proposed a General Extended Technology Acceptance Model for E-Learning (GETAMEL)”. In its proposition, GETAMEL did not consider cultural factors, system quality, information quality and service quality; rather, it focused on the most commonly used external constructs of TAM.

In order to investigate the advantages and disadvantages of e-learning in higher educational institutions, using TAM as an underpinning theory, [3], reviewed e-learning literature and found benefits of e-learning to its flexibility irrespective of time and place, its enhancement of knowledge, its ability to enable easy access to large amount of information, offer opportunity for improved interaction and its cost effectiveness.

Though TAM has broadly been applied on various technological novelties worldwide and has been fruitful in predicting acceptance behaviors in many settings, it might not hold true for all cultures [4]. On this basis, [5] unearthed technological acceptance concepts and subsequently developed an expanded TAM in the Sub-Saharan African context [6]. To assess the effectiveness of the developed model in the African context, this study examined the performance of the developed expanded TAM in Sub-Saharan African context. Unlike the earlier studies, that collected data from individual countries, [6] expanded TAM, based on data gathered from five universities in five Sub-Saharan African countries across the five Sub-Saharan African regions. To validate the model and ascertain its performance, this study subjected the model to experts’ review and variance measurements.

II. LITERATURE REVIEW

According to [7], “the Cognitive Dissonance Theory (CDT) and Expectancy Disconfirmation Theory (EDT) have proved relevant to technology acceptance through a few studies” like that of [8] and [9]. However, CDT and EDT do not address technology acceptance adequately and hence has not received the same consideration as Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM, TAM2 and TAM3). TRA, TAM, TAM2 and TAM3 are more popular technology

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acceptance theories/models and used worldwide in information system literature and fields [7] [10]. TRA has limitations and among these is the confusion between Attitudes and Norms: often Attitudes can be rephrased as Norms and vice versa [11]. A further limitation of TRA is the fact that freedom to act, is not limited as in reality, freedom to act may be limited by factors such as environment, time and level of ability.

Compared to TRA and EDT, TAM is favored as a technology acceptance model in the information systems industry. According to [12], "TAM is a valid and robust model". But not withstanding this, many researchers have proposed its expansion and others expanded it. Previous studies comparing technology acceptance models include studies by [13]. [13] Correlated eight models to postulate Unified Theory of Acceptance and Use of Technology (UTAUT) model. According to [7], the correlation by [13] is considered the most pragmatic model. In their studies, [14] confirmed that UTAUT has a higher explanatory power compared to other technology acceptance models and theories in the IS/IT industry. Notwithstanding its higher explanatory power, [15] pointed out weakness in it. According to [15], UTAUT moderators may not be applicable in all contexts. The said context could include the Sub-Saharan African environment and hence the need to develop an expanded TAM in the Sub-Saharan African context. [15] Further argued that a path from facilitating conditions to behavior intent is missing in the UTAUT model and also that the model failed to theorize the individual characteristics (such as attitude). Considering that individual characteristics is a cultural factor, then there was the need to develop an expanded TAM that considers the African culture.

In their study to "measuring Information systems success models", [16] compared among others, the "Information System Success Model" (ISSM), updated ISSM and TAM [17]. From the comparison, it's noticed that ISSM is the "first attempt to measure information system success". According to [16], "ISSM is the most popular among all the models given in the past" and TAM remains the most popular model in studying users' willingness towards accepting Information Technology [18], [19] and hence has broadly been applied on various technological novelties worldwide to fruitfully predict acceptance behaviors.

Considering the findings in various studies above that, existing technological acceptance models may not be applicable in some cultures, [5] study identified technology acceptance concepts (constructs and variables) that are applicable to the African environment and hence subsequently developed an expanded TAM in the African context [6].

[5] Study established four constructs and 14 associated variables for technological acceptance in the African environment. These constructs and variables are Perceived Ease of Use, Perceived Usefulness, Perceived Performance & Perceived Benefit and ease of use, system quality, usefulness, frequency of use, information quality, culture, satisfaction, experience, student or user centeredness, training, use mode, influence by peers, service quality & influence by important persons respectively.

Applying multiple regression analysis to probe the four constructs further, [6] proposed 13 hypotheses and analyzing the hypotheses further (as Table 1), developed the TAM for the

Sub-Saharan African environment. The developed TAM as illustrated in Figure 1 has four main constructs. Three of the constructs directly influence Behavioral Intention and one indirectly influence Behavioral Intention. All four main constructs are influenced by external factors. To validate the model and ascertain its performance, this study subjected the model to experts' review and variance measurements.

Table 1: P-values and β values

No	Hypothesis	Path	Standard Coefficient (β)	Probability Value P ($P \leq 0.05$)	Hypothesis Results Based on P-Value
1.	H1a	EF \longrightarrow PEOU	0.146	0.010	Accepted
2.	H1b	EF \longrightarrow PB	0.235	0.001	Accepted
3.	H1c	EF \longrightarrow PU	0.113	0.047	Accepted
4.	H1d	EF \longrightarrow PP	0.131	0.021	Accepted
5.	H2a	PEOU \longrightarrow PB	0.190	0.001	Accepted
6.	H2b	PEOU \longrightarrow PU	0.932	0.001	Accepted
7.	H2c	PEOU \longrightarrow BI	0.190	0.001	Accepted
8.	H3a	PB \dashrightarrow BI	0.015	0.790	Rejected
9.	H3b	PB \longrightarrow PU	0.411	0.001	Accepted
10.	H4a	PU \longrightarrow PB	0.202	0.001	Accepted
11.	H4b	PU \longrightarrow BI	0.202	0.001	Accepted
12.	H5	PP \longrightarrow BI	0.131	0.021	Accepted
13.	H6	BI \longrightarrow TA	0.113	0.047	Accepted

Source: [6]

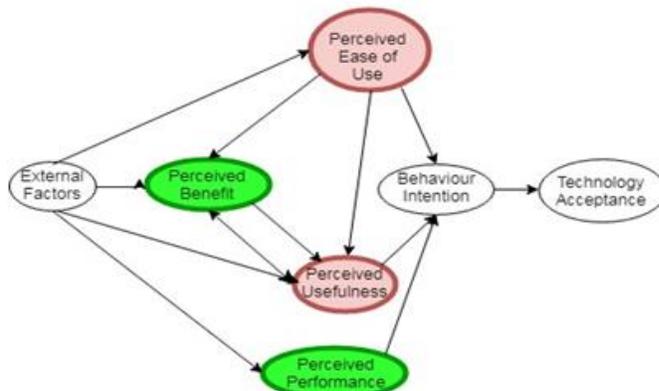


Figure 1: The Developed Model

Source: [6]

KEY: EF – External Factor, PEOU – Perceived Ease of Use, PB – Perceived Benefit, PU – Perceived Usefulness, PP – Perceived Performance, BI – Behavioral Intention, TA – Technology Acceptance

TABLE II: TELEPHONIC INTERVIEW WITH INFORMATION SYSTEMS EXPERTS

KEY to the Table items: EF – External Factor, PEOU – Perceived Ease of Use, PB – Perceived Benefit, PU – Perceived Usefulness, PP – Perceived Performance, BI – Behavioral Intention, TA – Technology Acceptance

No	Path in the Expanded TAM Model			Expert Confirmation of Acceptability of the Path (Relationship)						Mode of Model Distribution Model and Probability Values	Telephonic Interview		
				1	2	3	4	5	6		1	2	3
1	EF	→	PEOU	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
2	EF	→	PB	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
3	EF	→	PU	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
4	EF	→	PP	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
5	PEOU	→	PB	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
6	PEOU	→	PU	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
7	PEOU	→	BI	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
8	PB	→	PU	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
9	PU	→	PB	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
10	PU	→	BI	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok
11	PP	→	BI	Yes	Yes	Yes	Yes	*Yes	*Yes	Email	*Further Clarity Requested by Experts 5 and 6	Ok	Ok
12	PB	- - →	BI	Yes	Yes	Yes	Yes	*Yes	**Yes	Email	*Further Clarity Requested by Experts 5 and 6	*Further Clarity Requested by Experts 6	OK
13	BI	→	TA	Yes	Yes	Yes	Yes	Yes	Yes	Email	Ok	Ok	Ok

Key to the Table 2:
 → Accepted path in the model (relationship exist)
 - - → Rejected path in the model (no relationship exist)
 * Yes: Clarity Sorted on the construct by the expert in one of the first Interviews as experts thinks the path may not be correct as it is
 **Yes: Clarity Sorted on the construct by the expert in one of the first Interviews as experts thinks the path may not be correct as it is
 Ok: Expert agreed that the path is correct as postulated in the TAM expanded model in the African context

III. METHODOLOGY

As part of a wider study that unearthed technology acceptance concepts in the African context [5] and developed an expanded TAM in the African context [6], this study applied a quantitative research methodology to validate the model and measure its performance. Subjecting the model (Figure 1) and associated Probability and Standard Coefficient (P and β values; Table 1) to six information systems and human computer interaction experts’ opinion, through one email circulation and three telephonic interviews (at separate times), the experts validated the model. Through the email, the researchers circulated the model and its associated P and β values to the six experts. The three interviews were necessary as it allowed experts who needed to clarity on some concepts of the developed model to get further data and got telephonically interviewed the second time. The same applied again to move onto a third telephonic interview.

Using questionnaire to collect data from 308 students in five public universities (using e-learning systems) in five countries in the five regions of Africa, multiple regression analysis for variance for the independent and dependent construct (Perceived Usefulness - PU, Perceived Ease of Use - PEOU, Perceived Performance - PP, Perceived Benefit - PB and Behavior Intention - BI respectively) in the developed expanded

TAM was computed and compared with variance (R2) of constructs in the existing TAMs in literature.

IV. ANALYSIS AND DISCUSSION

As presented in Table 2, in the first telephonic interview, all six experts agreed that, 1. External factors influence the four main constructs of the developed expanded TAM model in the Sub-Saharan African context (see rows 1 to 4 in the table); 2. PEOU influence PB, PU and BI (see rows 5 to 7 in the table); 3. PB influence PU (see row 8 in the table); 4. PU influence PB and BI (see rows 9 and 10 in the table); 5. BI influence Technological Acceptance (see row 13 in the table). On the paths/association from PB and PP to BI, only four experts agreed (see rows 11 and 12 in the table; denoted by yes), that, it is correct as postulated in the developed expanded model; experts 5 and 6 requested for further clarity on the variables that influence PB and PP for more comprehension to enable them make informed inputs on the said paths/relationships.

As discussed between expert 5, expert 6 and the researcher, the researcher forwarded a write up on the variables and their description to experts 5 and 5, a day after the telephone call. After a week of studying the variables; another telephone interview (2nd telephone interview) took place between the researcher and experts 5 and 6 separately. In this interview, both experts 5 and 6 agreed that PP influence BI (see row 11 in Table 2: denoted by *Yes). Though expert 5 agreed that PB does not

influence BI (see row 12; denoted by *Yes), expert 6 further requested the researcher to send him additional description of the variables that influence PB. Based on this request, a third telephone interview was scheduled between the researcher and expert 6. Whiles awaiting for the third telephone interview to take place, the researcher conducted a second telephone interview with experts 1, 2, 3 and 4.

TABLE III: COMPARISON OF THE EXPLAINED VARIANCE AMONG PU, PEOU, PP, PB AND BI

Study	Country	Sample	Key Factors		Variance Explained R ²						
			Factor(s)	Effect Direction Towards	PU	PEOU	PP	PB	ATU	BI	
(Alenezi et al., 2010)	Saudi Arabia	480	Enjoyment, Computer Anxiety, Computer Self-Efficacy and Internet experience	BI	None	None	None	None	None	None	61%
(Al-Harbi, 2011)	Saudi Arabia	531	Accessibility, Computer Self-Efficacy, University Support, Interactivity, Flexibility, Internet Experience	BI PU PU PU and PEOU	56%	23%	None	None	None	None	43%
(Tslios et al., 2011)	Greece	102	None	None	37%	None	None	None	None	None	39%
Al-Aulamaie (2013)	Saudi Arabia	766	Enjoyment, Computer Playfulness, Learning Goal, Orientation, Information Quality, Accessibility, Functionality, Interface Design	BI Insignificant BI PU PU PU, PEOU and BI PU	59%	48%	None	None	None	None	56%
Liu (2014)	China	211	PU and PEOU PU, PEOU, PU and ATU	ATU PU, BI	None 53.9%	None None	None None	None None	None None	78.3% None	None 78.9%
Sasoi and Gao (2018)	Sweden	130	PMC and AR UMS ATU	PU PEOU	56% None None	None 23% None	None None None	None None None	None None None	None None None	None None 56%
Musa et al. (2018)	Malaysia	44	PU and PEOU PU and PEOU PU, PEOU and ATU	BI ATU BI	None None None	None None None	None None None	None None None	None 94% None	None None None	55.6% None 57.8%
Marbá and Muleña (2019)	Spain	163	IF IF, G IF, G, A, IF, GA, E	ATU	None None None None	None None None None	None None None None	None None None None	9.3% None 13.9% 17.1%	None None None 2%	None None None None
Sánchez-Prieto, et al (2019)	Spain	160	PU, PEOU and BI	BI	62%	21.3%	None	None	None	None	70.85%
Arias-Oliva, Pelegrin, Boron de, and Matias (2019)	Spain	402	PP, EE, EF	TPCK-W	None	None	None	None	None	None	84.8%
This Study	Africa (South Africa, Nigeria, Kenya, Sudan and DR Congo)	308	PU, PEOU, PP, B	BI	89%	89.2%	21.3%	28.2%	None	None	51%

In the interview, the researcher clarified to the experts about variables that influence PB and PP, and after asked, the experts if they were still standing by original opinion on the paths/association between PB, PP and BI and all other paths/association as they indicated in the first interview. To this, all four experts affirmed that, their opinion (denoted by *Yes in rows 1 to 13) remained the same. In the third telephone interview with the 6th expert, he agreed that, as in the model, PB does not influence BI. Results of the expert opinion and review above show that the model is acceptable for evaluating technology acceptance in the Sub-Saharan African environment.

Using the responses from the respondents, the variance of the four independent constructs (PU, PEOU, PP, and PB) and dependent construct (BI) were computed. Results in Table 3 show that the developed extended TAM model in the African context was able to explain the high variance in two of the independent constructs (PU and PEOU) and a moderate variance in the two new independent constructs (PP and PB). Further, the comparison, as listed in Table 6.1 indicates that the newly developed model explained variance outperformed that of the existing model, as found in literature, suggesting that PU, PEOU, PP, PB and BI are predictors of technological acceptance in the context of Africa. This, therefore, confirms the developed model's applicability to explain Technological Acceptance in the Sub-Saharan Africa.

As indicated in Table 3, the variance in PU and PEOU towards BI in the developed model is 89.0% and 89.2% respectively. Statistically, variance values are greater than 0 and less than 100% and this can be formularized as $0 < R^2 < 100\%$. The variance values in PU and PEOU towards BI (89.0% and 89.2%) in the developed model are very high (close to 100%); indicating that 89% and 89.2% of the variation in behavior Intention can be explained by PU and PEOU respectively and hence a strong relationship between PU, PEOU and BI.

As a result of the fact that External Factors do not influence BI directly and also that all previous studies on variance computation from 2011 to 2019 ([20], [21], [18], [22], [23], [24] and [25]) ignored it, this study left it out of the variance computation towards BI.

The research model was able to explain more variance in the two independent constructs; PU, PEOU and the dependent construct, BI. Additionally, the research was also able to explain the moderate variance in another two independent constructs: PP and PB.

The explained variance results for PU, PEOU, PP, PB and BI are 0.890, 0.892, 0.213, 0.282 and 0.510 respectively.

Table 3 demonstrates previous studies variance computation result in PU, PEOU towards BI: based on the existing TAM. The previous studies include the study of [5] in Saudi Arabia, [21] in Saudi Arabia, [22] in China, [18], [23], [24] and [25]. The variance value for PU, PEOU towards BI in the previous studies ranged from 21.3% to 62%.

To compare the performance of the existing model with the developed model, the variance in PU and PEOU towards BI in the developed TAM was computed and compared with the variance values of the existing TAM as reported in the previous studies for the period of 2010 to 2019 ([20], [21], [18], [22],

[23], [24] and [25]). The variance values in PU, PEOU towards BI (in the new model), ranged from 89.0% to 89.2%. Comparing the variance values in the previous studies (21.3% to 62%) to the current studies (89.0% to 89.2%), it is concluded that the developed model outperformed the existing model, as it accounts for more variance in PU and PEOU towards BI than the existing model. Based on the fact that, the larger the R^2 (variance) value, the better the regression model fits the observations [26], [27], then the result show a strong relationship between PU, PEOU and BI.

The explained variance for the two new independent constructs, PP and PB, were moderate (0.213 and 0.282 respectively). This indicates that 21.3% and 28.2% of the variation in BI can be explained by PP and PB respectively. Though this is not a high explained variance, it is still an improvement, as the previous studies had no explained variance at all for these two independent constructs. These results also suggest a moderate relationship between PP, PB and BI. Overall, this confirms a relationship between PU, PEOU, PP, PB and BI as predictors of technology acceptance in the context of Africa, confirming the expanded Technology Acceptance Model's applicability to predict and explain Technological Acceptance, in Africa.

V. CONCLUSION AND RECOMMENDATION

Six experts validated the [6] expanded TAM model in the Sub-Saharan African context as valid. In relation to other TAM models, the performance of the TAM model in the African context was assessed using the explained variance in Perceived Usefulness, Perceived Ease of Use, Perceived Performance, Perceived Benefit and Behavioral Intention. The assessment results showed that the research model outperformed the existing TAM and extension / expanded TAM models. Though this research was able to reach some stimulating findings as above, it had a limitation of not being able to collect primary data on existing TAM models to use to compute their variance. Unlike the developed expanded TAM model in the Sub-Saharan Africa context where primary data was applied in computing the variance, for the existing TAMs, the variance were adopted from literature. Future research in this area should consider collecting primary data on the developed expanded TAM model and existing TAM model so as to ascertain if the results could validate this research findings.

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