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Eco-System Oriented Instrument for Measuring Firm Technology Adoption

(Full Paper)

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ABSTRACT

The development of the Firm Technology Adoption Model (F-TAM) of measuring firm technology adoption at the SME level addressed an important knowledge gap from a developing country context. The model, however, lacked a measuring instrument to allow researchers to engage the model empirically. In this study, a measuring instrument is designed, taken through self-review, expert review, focus group discussion, and then a pilot test. Statistical analysis of the pilot test shows that the instrument is both a valid and reliable for measuring SME innovation adoption from an ecosystem perspective. This paper, therefore, opens up new avenues for both industry and academic works on the adoption of digital innovations.

Keywords: F-TAM, measuring instrument, mobile technologies, SME adoption, developing country contexts.

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INTRODUCTION

Industry and academic interest in understanding and promoting the adoption of digital technologies at the firm level is still ongoing (Akman & Turhan, 2018). This interest has intensified in the past couple of years in Ghana (National Communications Authority -NCA, 2016; Bank of Ghana, 2016; Doe, Van de Wetering, Honyenuga, & Versendaal, 2017), a development that heightens the need for context-relevant models (Iqbal & Qureshi, 2012) that explain the adoption of digital technologies. The context-relevant models are significant because studies such as Data (2011) reported that earlier models of technology adoption had realized mixed results when they are tested in developing country contexts. In an attempt to develop a model that illustrates adoption at the micro, small to medium scale enterprise levels in developing country contexts, Doe et al. (2018) contextually validated the Firm Technology Adoption Model (F-TAM) as a more realistic way of measuring firm technology adoption in developing country contexts. A significant setback of Doe et al. (2018), however, was the absence of a measuring instrument (questionnaire) to test that model, just as Technology Adoption Model (TAM), Decomposed Theory of Planned Behavior (DTPB), Unified Theory of Acceptance and Use of Technology (UTAUT), and Integrated Model of Technology Acceptance (IMTA) have had. The lack of an instrument makes the testing of the revised F-TAM a thorny issue, raising such essential questions as:

a. *What instrument can be applied to measure the firm-level adoption of digital innovations using the F-TAM model?*
b. *Has the instrument been developed with cognizance of the contexts of SMEs in developing countries?*

This study is positioned to address these research questions and, therefore, aims to develop and field-test a reliable and valid instrument for measuring F-TAM.

THEORETICAL BACKGROUND

Context Of The Study

Developing countries are those that have low to middle income (0 - $3,255 per capita income) (World Economic Forum, 2015) and described by Bannock (2005) as countries that have reached neither growth of industrialization nor a level of national income sufficient to finance investment for further growth. Ghana falls within this category of country classification due to her lack of domestic savings required to finance investment for further growth, such as the mass adoption of mobile technology innovations. In such countries, SMEs live with the digital divide, which is invariably a poverty gap (Zachary, 2002). The Ministry of Trade in Ghana defines micro to medium-sized enterprises as any organization that employs between 1 to 5 persons to be micro-enterprises, 6 to 29 people with total assets less than $100,000 as small enterprises and 30 to 99 people with total assets of up to $1 million as a medium enterprise (Mensah, 2004). SMEs would have to adopt innovations more quickly due to fewer bureaucracies however they are hindered due to inadequate telecommunications infrastructure, lack of

payment options, legal and regulatory issues, trust and security, socio-cultural factors, and lack of skills in the workforce (Karanasios, 2008).

Theories Of Adoption

Innovation is the design or adoption of an idea, physical artifact, conduct, invention, technology, or a process that is new to the adopting unit (Gupta, Tesluk & Taylor, 2007). Digital innovation is an innovation that if enabled by digital technologies. Digital technologies may be disruptive (Christensen, Christensen & Raynor, 2003), such that they create new markets and value, thereby upsetting existing industry structures, and established market leaders (Christensen & Raynor, 2003).

Innovation is adopted at a personal level, firm-level, and societal level (Rogers, 1962). Theories of adoption can also be similarly classified into three groups of personal adoption theories, firm adoption theories, and societal level adoption theories (Doe et al., 2017). Models that are specific to the study of technology at the personal level only include the Integrated Model of Technology Acceptance -IMTA (Venkatesh, Speier & Morris, 2002), Technology Acceptance Model -TAM (Venkatesh & Bala, 2008), Unified Theory of Acceptance and Use of Technology -UTAUT 1 & 2 (Venkatesh, Thong & Xu, 2012), and Dynamic Use Diffusion Model (DUDM) (Shih, Venkatesh, Chen, & Kruse, 2013). Specific models for the study of societal level adoption only include Culture, Policy & Technology Framework (CPT) (Bajaj & Leonard, 2004). At the firm level, models such as Technology, Organization and Environment Framework (TOE) (Tornatzky, Fleischer & Chakrabarti, 1990), Task-Technology Fit (TTF) (Goodhue & Thompson, 1995), and Perceived Electronic Readiness Model (PERM) (Molla & Licker, 2005) have been used to study firm adoption in the past. None of these earlier models attempt to examine how the different levels have any interactive effect. A currently interactive model proposed for use at the firm level is the F-TAM (Doe et al., 2018).

The F-TAM Model

The Firm Technology Adoption Model (F-TAM) was birthed in Doe, Van De Wetering, Honyenuga, & Versendaal (2017) as an initial step toward the development of a context-specific model of firm technology adoption for developing countries. This was done through a systematic literature review and analysis. The F-TAM posited four factors at the personal/employee level, five factors at the firm level and four factors at the societal level that inter-relate to realize firm-level adoption of digital innovations. The initial F-TAM model was however not validated contextually. To examine the degree to which F-TAM reflect the adoption pattern among SMEs in Ghana, and whether changes in the model would make the model more valid, Doe, Van de Wetering, Honyenuga & Versendaal (2018) contextually validated the initial F-TAM model through two rounds of Delphi panel interviews of both academics and industry experts. The validation study (Doe et al., 2018) discovered new constructs and propositions that made the original F-TAM more realistic to developing country SMEs.

The F-TAM model proposes that employee-level variables (personal level factors) of *Perceived Ease of Use, Perceived Usefulness, Perceived Indispensability, Perceived Social Influences*, *Trial Feedback*, and *Employee Self Enhancement Motives* will collectively lead to firm adoption, and influence firm factors of adoption. At the firm level, the revised F-TAM (Doe et al.,2018) decomposes the general firm-level factors into internal organizational factors such as *Technological Readiness Managerial Innovativeness, Organizational Readiness, Strategic Fit with Operations, Ease of Support, and Organizational Culture;* as well as firm industry factors such as *Customer Needs/Demand, Competitive Pressure,* and *Partner Requirement*. The model posits that these factors will combine at the firm level to influence firm adoption. Societal level factors proposed in the revised F-TAM (Doe et al., 2018) are *Government Policy, Government Championship, Government Laws, Innovation Infrastructure, Opinion Leadership,* and *Successive Government Commitment.*The model posits that these factors will, taken together, lead to firm adoption, influence employee factors, influence firm factors and moderate the relationship between firm factors and firm adoption. The revised F-TAM places emphasis on the technology characteristics as a strong influence on individuals, firms, and society at large. These technology characteristics are *Observability, Flexibility, Complexity,* and *Relative Advantage* (Rogers, 1962). Doe et al. (2018) propose that the characteristics of the innovation/technology will influence employee level factors, influence firm-level factors, and influence societal-level factors.

The significant novelty of the original F-TAM, as well as the revised F-TAM, is that it posits antecedents of firm-level adoption and at the same time scrutinizing for the impact on the individual (employee) adoption and societal adoption. This is viewed as an eco-systems perspective of examining the adoption of an innovation, which is a novel viewpoint of studying adoption at any level.

The eco-system view of adoption has been prompted by researchers on innovation eco-system (Gobble, 2014; Adner, 2006; Groth, Esposito, & Tse, 2015) who emphasise the need to examine innovation as a member of a system of parts that contribute for the innovation to succeed. This view is adapted in examining adoption at the firm level. Thus the eco-system is operationalised in this study as the different levels of adoption and the technology itself.

Theories Of Measurement

Three categories of theories have been posited as a guide in developing measuring instruments. These are the representational, operational, and classical theories. The *Representational Theory* (Stevens, 1959) suggests that numbers can be used in measurement to represent empirical relations between objects. This view is emphasized by Townsend and Ashby (1984) in that "measurement is (or should be) a process of assigning numbers to objects in such a way that interesting qualitative empirical

relations among the objects are reflected in the numbers themselves as well as in important properties of the number system." In line with this theory, Stevens (1946) distinguishes four scales of measurement: nominal, ordinal, interval, and ratio scales. The ***Operational theory*** derives from the methodological literatures of Bridgman (1927), who aptly summed up measurement as "a concept is nothing more than a set of operations; the concept is synonymous with the corresponding set of operations", emphasized by Dingle (1950) as "any precisely specified operation that yields a number". For the operational theory, numbers do not point beyond themselves to a scale-free realm. For operationists, "science is simply the study of our operations and not the study of a reality that is thought to lie beyond them" (Michel, 1986). The ***Classical theory*** is emphasized in Fechner's (1966) assertion that "measurement of a quantity consists of ascertaining how often a unit quantity of the same kind is contained in it", and Titchener's (1905) observation that measurement in any natural science is comparing a given magnitude with some conventional unit of a similar kind. Thus, according to this theory, measurement is "the assessment of quantity" (Rozeboom, 1966), the estimation of "how much" (Michel, 1986). Proponents of this theory are only concerned with how much there is of a given attribute (mass, intelligence, etc.)

Instrument Development

In providing guidelines for instrument development, Leeux et al. (2008) identified three stages of developing a finalized questionnaire (instrument), namely: the developmental stage where the subject matter being studied is explored through literature, when cultural and language issues that can affect the instrument are addressed (Cannell, Oksenberg, Kalton, Bischoping & Fowler, 1989); the question testing stage where each question is tested for the principles of a good questionnaire and the dress rehearsal stage where the questionnaire is tested under real survey conditions (Leeux et al., 2008).

Question development

To facilitate consistency in response, Leeux, Hox, and Dillman (2008) provided a framework of asking questions for respondents to answer. Leeux, et al. (2008) argue that, for a respondent to answer a question, the respondent must understand the question, have or retrieve the information needed to answer the question, translate the information into the form required to answer the question and provide the answer by writing, telling, entering or ticking (Leeux et al., 2008). Asking the right questions implies that the interviewer chooses the right vocabulary suited to the target respondents. Such questions must avoid ambiguity, embedded assumptions (Fowler, 2004), and multiple items in questions, while providing an indication of time frame of information required (Leeux et al., 2008). For respondents' ability to retrieve information needed to answer questions, Schuman & Presser (1981) discusses in detail how researchers can unintentionally ask questions that respondents do not have answers to, causing them to create answers. These, in addition to the need to eliminate recall problems (Tourangeau, Rips & Rasinski, 2000), are essential elements that Leeux et al. (2008) advise researchers to pay heed to in this regard. To facilitate development of appropriate responses, Leeux et al. (2008) suggest that question items must have clear response tasks by having response options that are obvious, matches the question, do not assume regularity and should be mutually exclusive and exhaustive.

Question testing and dress rehearsal

In the words of Sudman and Bradburn (1982), "even after years of experience, no expert can write a perfect questionnaire". They further recommended that, where a researcher does not have the resources to pilot-test a questionnaire, that researcher needs not to conduct the survey. In the same vein, Van der Zouwen & Smit (2004) observed that even an expert review of a questionnaire can be very different from a field test of the questionnaire. A field test is, therefore, the surest way to validate a research instrument within the comprehension, recall, judgment and response framework (Tourangeau, 1984; Leeux et al., 2008). Testing questions can be formal or informal. Informal testing includes reading questions to oneself, self-interviews (acting as the respondent), and mock interviews (listening to a colleague being interviewed) (Leeux et al., 2008). A formal field test involves administering the questionnaire on a sample of real members of the population (Leeux et al., 2008). Newer methods of questionnaire testing include: expert reviews (Thomas, 2002); systematic reviews (Forsyth, Hubbard & Lessler 1992); respondent debriefing, referred to in the literature as special probes (Oksenberg, Cannell & Kalton, 1991) or frame of reference probing (Demaio, 1984); behaviour coding (Fowler & Cannell, 1996); cognitive interview (Casper, 2004); and focus group discussions (Morgan, 1988; Stewart & Shamdasani, 1990).

Reliability and validity of the instrument

To discern reality (Smallbone & Quinton, 2004) in behavioral research, measurement instruments must be valid and reliable (Drost, 2011). For every construct, a large number of operational definitions are possible. Therefore it takes creative insight, good judgment, and relevant theory to develop the operational definition that is accurate for the study at hand (Leeux et al., 2008). Subsequently, if a measuring instrument is to produce usable data, it needs to pass the reliability and validity tests (Straits & Singleton, 2011).

Reliability of an instrument requires that the instrument can measure an attribute or attitude consistently and dependably (Straits & Singleton, 2011). In other words, reliability is the degree to which measurements are repeatable under different conditions. This is consistency of measurement (Bollen, 1989), the stability of measurement over varied conditions (Nunnally, 1978), and indicated as a reliability coefficient (Rosnow & Rosenthal, 1991). Common methods of evaluating reliability in behavioral research include test-retest reliability, alternative forms, split-halves, inter-rater reliability, and internal consistency. These address the three main concerns in reliability testing of equivalence, stability over time, and internal consistency (Drost,

2011). For a satisfactory level of reliability, Nunnally (1978) suggests that reliabilities of .70 or higher should be sufficient for the social sciences. Nunnally (1978) maintains that increasing reliabilities much beyond .80 is unnecessary.

Validity, on the other hand, refers to the congruence of fit (goodness of fit) (Straits & Singleton, 2011) between the items that seek to measure a construct. Validity measures whether the operational definition and items under a construct indeed measure what the construct means accurately (Combach & Meehl, 1995). In this vein, an unreliable instrument is often not valid (Davis, 1971). The four types of validity researchers must consider are statistical conclusion validity, internal validity, construct validity, and external validity (Drost, 2011).

Theoretical Underpinnings Of Current Study

This current study engages the representational theory to develop an instrument for the context relevant model of F-TAM. This approach is consistent with the instruments associated with other models such as CPT framework, PEERM, and TTF models. In this approach to instrument development, numbers represent an empirical relational system, which exists quite independently of our operations, and are used as a convenience and are, in principle, dispensable. The instrument development followed De Leeux et al.'s (2008) three stages of developing a finalized questionnaire (instrument). These are: I) the developmental stage where the subject matter being studied is explored through literature; II) the question testing stage where each question is tested for the principles of a good questionnaire; and finally, III) the dress rehearsal stage where the questionnaire is tested under real survey conditions.

METHODS

To develop the measurement instrument, we followed Churchil's (1979) process to specify construct domain, generate a sample of items, collect data, purify measure, collect data again, assess reliability, assess validity, and develop norms. Using the domains and variables of Doe, Van de Wetering, Honyenuga, Versendaal, & Boateng (2018), question items for this instrument were either adapted from relevant previous studies, or crafted and were reviewed for length (Holbrook et al., 2006), grammar (Leeux et al., 2008), simplicity (Bhandari & Wagner, 2006), social desirability (Brace, 2004), double-barreled questions (Leeux et al., 2008), and question order (Baker, 2003). The checking process was done through self-review, expert review and focus group discussions (Leeux et al., 2008).

Self-review- The authors went through the adapted or constructed questions one by one to make a judgment on translation validity (face validity and content validity) (Trochim, 2006; Leeux et al., 2008).

Expert review- Two primary goals of an expert review are to reveal problems with a survey instrument so that they can be remedied before going into the field or to sort items into groups that are more or less likely to exhibit measurement errors (Holbrook et al., 2007). Four experienced academic researchers in the areas of technology and innovation adoption also reviewed the questions and gave feedback (Trochim, 2006). This improved the translations validities dimensions of construct validity (face validity and content validity).

Focus group discussion- A focus group of 12 academics (Collins, 2002) in Ghana was conducted as the final stage of the qualitative questionnaire development and review process. The focus group discussion on the questionnaire lasted for two hours. During this session, each participant was allowed to suggest changes to the questionnaire, and it was discussed. Suggestions that were accepted were included in the final questionnaire for field testing. This also further translations validities dimensions of construct validity (face validity and content validity) (Trochim, 2006). Due to the varied background of the focus group participants, this process also enhanced the external validity of the instrument constructs (Trochim, 2006).

Table 1 illustrates the sources of the variables from each construct. A pilot test of this research instrument was necessary to examine the statistical validity of the instrument.

Insert table 1 here. See Appendix B.

The field test of the questionnaire was done as the second phase of the questionnaire validation process (De Leeux et al., 2008). A middle ground of 25 samples was found between pilot study sample size suggestions of 15 to 35 (Fowler, 1995), 25 to 75 (Converse & Presser, 1986), 10 to 25 (Sheatsley, 1983), and 20 to 50 (Sudman, 1983). These samples were taken purposefully from sub business districts in Greater Accra, the most cosmopolitan region of Ghana. Responses were taken within three days. Interviewers were experienced field data collectors. Interviewers were not allowed to change questions (Converse & Presser, 1986).

RESULTS OF THE PILOT STUDY

The results from the data analyzed for the pilot study are shown below:

Validity Analysis

Face validity is deemed to be addressed through the review process of self-review, expert review, and focus group discussions (De Leeux et al., 2008).

To obtain convergence validity, several authors recommend having a minimum composite reliability of 0.7 and a minimum average variance extracted estimate of 0.50 (Gerbing and Anderson, 1988, Hair et al., 2016,). From the pilot test, composite reliabilities (CR) ranged from 0.742 to 0.885, and average variance extracted (AVE) estimates ranged from 0.515 to 0.780, all meeting the minimum recommended by Hair et al. (2016) for adequate convergence validity.

Discriminant validity is met by the fact that the square root of the minimum average variance extracted (AVE) is higher than the biggest inter-construct correlation (Fornell and Larcker, 1981; Barclays et al., 1995; Hair et al., 2016). Therefore, each construct is unique and differs from the other constructs in the model. Hence discriminant validity is adequately met.

Reliability Analysis

As a common rule, a reliability coefficient, Cronbach's alpha values, that is greater than or equal to 0.7 is thought to be acceptable and a good indicator of construct reliability (Nunnally, 1978). However, values lower than 0.7 may be acceptable for exploratory research. Hair, Anderson, Tatham, and Black (1998) recommend a cut-off point of 0.6 as the lower limit of acceptability.

Correlation Matrix (Pearson R)

Table 2 presents the results of Pearson inter-construct correlations performed for the pilot data. The results show that the correlations between the twenty-six constructs were mostly positive and significant.

Although some of the correlations were very low or very high, this is to be expected since the constructs used to perform the computations were mainly low-level constructs, which might reveal moderate to high correlations among constructs within the same formative high-level construct. For example, technological factors (a high-level construct) such as flexibility, observability, complexity, and relative advantage mainly had moderate to high correlations between them. Due to the small sample size (n=25) used for the pilot study, it is inconclusive to assume multicollinearity or violation of discriminant validity at this pilot study stage.

Insert table 2 here. See Appendix B

CMV Bias Analysis

A principal component analysis conducted on the data gathered for the pilot study, with the extraction of only one factor, showed that the factor accounted for 28.14% of variance explained, which is less than 50% variance, hence common method variance bias is absent from the data (Podsakoff et al., 2003).

KEY FINDINGS

We used a sample of 25 firms for reliability analysis. The overall reliability for the 109-item scale is 0.973, which indicates high internal consistencies and appropriateness of the data instrument (questionnaire) used in this study (Nunnally, 1978). Very high Cronbach's alpha values were obtained for firm adoption (0.836), personal/employee factors (0.874), firm internal factors (0.942), firm external factors (0.927), societal factors (0.937) and technological factors (0.901) scales, respectively. These outcomes indicate high internal consistencies and appropriateness of the data instrument (questionnaire) used in this study (Nunnally, 1978). Furthermore, each of the constructs under firm internal factors, firm external factors, societal factors, and technological factors had Cronbach's alphas of at least 0.6, which is acceptable for an exploratory study.

One of the variables under personal/employee factors, namely perceived indispensability, had Cronbach's alpha < 0.60. Further analysis suggests that the deletion of the third item under perceived indispensability, which reads as "Mobile money innovation is central for me on the job I do" would increase the Cronbach's alpha to 0.648. Alternatively, a larger sample, or changing the question item would improve the reliability. Below are the reliability assessments for each variable.

Table 3: Reliability Analysis of Adoption

	Number of items	**Cronbach's α**	**Mean**	**Variance**
Firm Level Adoption of MoMo Innovations	5	0.836	3.925	0.158

Table 4: Reliability Analysis of Personal/Employee Factors

Personal/Employee Factors (Cronbach's α= 0.874)	**Number of items**	**Cronbach's α**	**Mean**	**Variance**
Perceived Ease of Use	4	0.808	4.160	0.021
Perceived Usefulness	4	0.787	3.450	0.049
Perceived Indispensability	4	***0.591***	2.840	0.145
Perceived Social Influences	3	0.786	3.147	0.017
Trial Feedback	4	0.717	3.780	0.062
Empl. Self Interest/Enhancement Motives	4	*0.663*	3.310	0.071

Utilised Cronbach's alpha <0.7; **Bold** and *Italised* Cronbach's alpha is below the minimum level of 0.6.

Table 5: Reliability Analysis of Firm Internal Factors

Internal Factors (Cronbach's α= 0.942)	**Number of items**	**Cronbach's α**	**Mean**	**Variance**

Technological Readiness	4	0.903	3.100	0.118
Managerial Innovativeness	4	0.823	3.490	0.084
Organisational Readiness	4	0.745	3.360	0.031
Strategic Fit with Operations	4	*0.677*	3.320	0.035
Ease of Support	4	0.831	2.780	0.104
Org. Culture (Firm propensity to take risk)	4	0.848	3.680	0.073

Utilised Cronbach's alpha <0.7

Table 6: Reliability Analysis of Firm External Factors

External Factors (Cronbach's α= 0.927)	**Number of items**	**Cronbach's α**	**Mean**	**Variance**
Organisational Partner Requirement	5	0.857	3.544	0.023
Competitive Pressure	4	0.825	3.360	0.007
Needs of Customers	5	0.812	3.472	0.086

Utilised Cronbach's alpha <0.7

Table 7: Reliability Analysis of Societal Factors

Societal Factors (Cronbach's α= 0.937)	**Number of items**	**Cronbach's α**	**Mean**	**Variance**
Government Championship	7	0.854	3.589	0.024
Government Policy	4	0.823	3.170	0.041
Government Regulation/ Laws	4	*0.698*	3.170	0.030
Innovation Infrastructure	4	0.753	3.610	0.060
Opinion Leadership	4	0.824	3.610	0.013
Successive Government Commitment	4	0.852	3.500	0.020

Italicized Cronbach's alpha <0.7

Table 8: Reliability Analysis of Technological Characteristics

Technology Factors (Cronbach's α= 0.901)	**Number of items**	**Cronbach's α**	**Mean**	**Variance**
Flexibility	4	0.837	3.970	0.016
Observability	4	0.704	3.700	0.054
Complexity	4	0.758	3.230	0.138
Relative Advantage	4	***0.674***	3.620	0.171

Italicized Cronbach's alpha <0.7

DISCUSSIONS

Tables 3 to 8 show that most of the constructs achieved the minimum reliability index of 0.7 (Nunnally, 1978). However, a few constructs achieved 0.7 through statistical approximation. These are 0.674 (relative advantage); 0.698 (Government Regulation/ Laws); 0.677 (Strategic Fit with Operations); and 0.663 (Employee Self Interest/Self Enhancement Motives), which are also acceptable for exploratory study (Hair, Anderson, Tatham, & Black, 1998). In the case of the constructs under personal/employee factors, perceived indispensability had Cronbach's alpha value of 0.591, which is approximately 0.60 (Hair et al., 1998). The item was left as it is because its reliability could improve using a larger sample size. The authors, therefore, believe that the questionnaire is valid and reliable. The final instrument is shown as Appendix A attached. The F-TAM questionnaire (Measuring instrument) is expected to measure the adoption of digital technology innovations and, by extension, is generalizable to other innovations at the micro, small to medium scale enterprise levels. It may similarly measure the adoption of digital innovations at the large firm-level.

While the academic report on pilot studies is rare in the research literature (VanTeijlingen *et al*. 2001) and sometimes considered a waste of time, the scholarly work of Friedman (2013) justified reporting the results of pilot studies. Meta-analysis studies, for instance, rely on pilot studies as well as empirical studies with large samples (Hazzi & Maldaon, 2015). Strengths and weaknesses of a measuring scale, as well as reasons of failed pilot studies that do not lead to a full-scale study, needs to be reported and understood (Hazzi & Maldaon, 2015). Thus pilot studies also help to design a realistic and workable research protocol. Outcomes of a pilot study enable researchers to decide what critical resources are needed in a more extensive study, persuade more scholars as well as grant reviewers, investigators, and other stakeholders of the relevance of a large study (Leon, Davis, Kraemer, 2011). De Vaus (1993) had also made a recommendation summarised as "Do not take the risk. Pilot test". To substantiate this trend of thought, Hazzi and Maldaon (2015) report that, from their experiences, the measurement of a construct must proceed through the conduct of (a) a pilot study first considering the issue of checking the reliability with Cronbach's alpha; (b) the main study considering reliability again, and reporting the results; (c) comparing those results (the pilot and main study); and (d) deletion of items, which have common problems of reliability. The significance of this study, therefore, is that it provides a tested measuring instrument that examines firm technology adoption from an eco-system perspective. This is signficantly different from other instruments that have been used in measuring firm adotion of any innovation.

CONCLUSIONS & RECOMMENDATIONS

This study sought to develop and field-test a reliable and valid instrument for measuring firm technology adoption using variables in the F-TAM. The study went through the instrument developmental stage, the question testing stage, and the dress rehearsal stage (De Leeux et al., 2008). At the end of the process, reliability values for all constructs were within the acceptable limits of ≤ 0.6, for exploratory studies. The instrument is, therefore, valid and reliable for measuring the F-TAM in a developing country context. The research gap identified is filled.

Further research on investigations on the factors that engender the adoption of digital innovations in developing country contexts can now be done with the F-TAM, using a reliable instrument. In applying this instrument, however, we suggest the use of larger samples. Further studies may discriminate between micro firms, which are mostly non-formalized and small to medium firms that are more formalized. The instrument reported in this study is currently most useful in developing country contexts. Users of this instrument need to ensure congruence between the contexts of Ghana and the socio-economic development, and e-readiness contexts within which this may be applied. The instrument is not applicable under mandatory adoption conditions that may exist for some firms. It applies in voluntary firm-level adoption conditions, which the F-TAM was developed for. This paper is the first attempt to develop an independent scale to measure the adoption of digital technologies in a developing country context at the SME level. We recommend further studies in testing the F-TAM model, using this instrument.

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Appendix A: F-TAM QUESTIONNAIRE

NB:1= Strongly disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly agree

Firm-Level Adoption Of Mobile Money Innovations
My firm has officially adopted mobile money technology for business purposes
Our employees know how to process mobile money payments
Our employees know that mobile money is acceptable in the firm
Our customers are able to make payment with mobile money
We are able to pay our suppliers with mobile money

Personal /Employee factors
Perceive ease of use (PEOU)
I am confident in using mobile money innovations
Using mobile money innovation does not require a lot of my mental effort
I find mobile money innovation to be less stressful
I find it easy to get mobile money innovation to do what I want it to do.

Perceived usefulness (PU)
Using mobile money innovation makes me efficient at the job I do
Using mobile money innovation for my job increases my productivity.
Using mobile money innovation enhances my effectiveness in the job I do
I find mobile money innovation to be valuable for the job I do

Perceived indispensability (PI)
Without mobile money innovation, I cannot function well in my job
Mobile money innovation is a neccessity for me
Mobile money innovation is central for me in the job I do
Working without mobile money innovation will be difficult

Perceived social influences
People who influence my behavior think that I should use mobile money innovation for my business/job
People who are important to me think that I should use mobile money innovation
My industry leaders encourage the use of mobile money innovation

Trial feedback
I can easily get information on how mobile money works
I still use mobile money because I don't have any negative experience with the usage
I have tried money in the past before using it in the firm
Before my firm adopted it, I had had a good experience with mobile money usage

Employee self interest/ self enhancement motives
I use mobile money innovations to create a good impression on others in the firm
I use mobile money innovations because it enables me to perform better on my job
The use of mobile money innovations helps me get more promotions due to efficiency
The use of mobile money innovations helps me get more sales due to efficiency

Firm Internal Factors
Technological readiness
In my firm (company) we have sufficient technological resources to implement mobile money innovation
We allocate a percent of total revenue for mobile money innovation implementation
We have the required technology infrastructure to use mobile money innovation
We have knowledgeable persons to use mobile money innovation

Managerial innovativeness
In my firm, top management of our organization are creative in their methods of operation
Management actively seeks innovative ideas
My top management is willing to take risks involved in the adoption of innovations such as mobile money
Top management actively introduce improvements and innovations in our organization

Organizational readiness
My organization is ready to embrace new mobile money innovations
My organization has a formal strategic plan for mobile money innovations use

My organization has a set of clear priorities for our mobile money innovation
My organisation commits personnel to the adoptoin of mobile money usage

Strategic fit with operations
Mobile money innovation services are compatible with existing technological infrastructure of my company
Customization of mobile money innovation services is easy
The changes introduced by mobile money innovation are consistent with existing practices in my company
Mobile money innovation is compatible with the firm's existing format, interface, and financial transactions

Ease of support
Staff levels of understanding was substantially improved after going through the training on mobile money innovation
The company provides staff training in using mobile money innovations
The training given to employees gives them confidence in the use of mobile money innovation
It is easy to get technical assistance in using mobile money in the firm

Organizational culture (Firm propensity to take risk)
Employees in our organization are encouraged to take calculated risks with new ideas
Our organization emphasizes exploration of opportunities
Our organization emphasizes experimentation for opportunities
Our organization is open to new ideas

Firm External Factors
Organization partner requirements
Our partners need us to use mobile money innovation during our transactions
It is mandatory to use mobile money innovations in dealing with our partners
It is easier to use mobile money innovation is dealing with our partners
Our partners prefer to use mobile money innovation for payment and receipts
The easiest way to do a financial transaction with partners is mobile money innovations

Competitive pressure
We are aware of mobile money innovation implementation in our competitor organizations
We understand the competitive advantages offered by mobile money innovation in our industry
Our competitors will gain a competitive advantage over us if we do not implement mobile money innovation
We will be left behind in this industry if we do not implement mobile money innovations
Needs of customers
Our customers need us to use mobile money innovation during our transactions
It is easier to use mobile money innovation in dealing with our customers
Our customers prefer to use mobile money innovation for payment
The easiest way for financial payment by customers is a mobile money innovation
The only way to receive payment from our customers is to use mobile money innovation

Societal Factors
Government championship
Government's drive for mobile money innovations applications will make us adopt further applications
When government promotes mobile money innovations as opportunities for the future, we are more likely to adopt it
When government removes obstacles for using mobile money, we are more likely to adopt further applications
Government expresses strong conviction about the potentials of mobile money innovation
Government points out reasons why the mobile money innovation is needed
Government shows persistence in overcoming mobile money innovation obstacles
Government gets key decision makers involved in mobile money innovation

Government policy
Government policy on mobile money innovations gives us the confidence to adopt it
Government is proactive in making mobile money acceptable for trading
The existing policies on mobile money are favourable
The taxes on mobile money usage are manageable

Government regulations/ laws
The laws of Ghana support mobile money innovations
If Ghanaian laws prohibit mobile money innovations, we will not adopt it
If any mobile money transaction goes wrong, we are sure of getting recourse in the law courts
We have confidence in mobile money transactions because the government has laws that regulate it

Innovation infrastructure
There is enough infrastructure in Ghana for mobile money innovations
The banks are ready to support mobile money applications
Mobile money innovation can be deployed on any mobile phone type
The telecom companies have enough infrastructure to support mobile money applications

Opinion leadership
In general opinion leaders and the media talk about mobile money innovations very often
When the media discusses mobile money innovations, we get a great deal of information
Apart from my organization's stake holders, we are likely to seek information from other people about mobile money
In the discussion of mobile money, my organization is likely to listen to expert opinion

Successive government commitment
Since 2005, all governments that come to power give attention to mobile money operations in Ghana
No government can afford to neglect mobile money operations in Ghana
Mobile money operations are too important for any government to ignore
We adopt mobile money because every governments will support its use

Technology Characteristics
Flexibility
Mobile money is a flexible payment option
Mobile money is readily adaptable to our business processes
With mobile money, our organization became more flexible with customers
We quickly meet many of our financial obligations using mobile money

Observability
We have had evidence of how mobile money helped organizations to succeed
It is easy to discern how mobile money works
It is easy to observe how mobile money makes transactions flexible
The growth of mobile money innovations usage by other firms is easy to observe

Complexity
Mobile money innovations are flexible to interact with (-)
Using mobile money innovations exposes the firm to the vulnerability of digital innovation breakdowns and loss of data
When we use mobile money, we find it difficult to integrate our existing work with the existing formats of business.
When we perform many tasks together, mobile money innovation takes up too much of our time

Relative advantage
Using mobile money innovations, we can scale up our financial requirement when needed
Using mobile money innovations, we can execute payment any time and from any place
Performance of mobile money innovation services does not decrease with a growing user base
In using mobile technology innovations, we need not to maintain our IT infrastructure

Appendix B. Table 1:Sources of the variables from each construct in the F-TAM model

Domain	Constructs (F-TAM)	Number of items	Source of items/	Usage mode
Firm Adoption	Firm Adoption	5	Authors	Self-constructed
Personal factors	*Perceive Ease of Use (PEOU)*	4	Venkatesh and Bala (2008)	Adapted
	Perceived Usefulness (PU)	4	Venkatesh and Bala (2008)	Adapted
	Perceived Indispensability (PI)	4	Shih, Venkatesh, Chen, and Kruse (2013)	Adapted
	Perceived Social Influences (PSI)	3	Shih, Venkatesh, Chen, and Kruse (2013)	Adapted
	Trial Feedback	4	Rogers (1962)	Adapted
	Employee Self Interest/ Self Enhancement Motives	4	Yun, Takeuchi, and Liu (2007)	Adapted
		4	Molla and Licker (2005)	Adapted
Firm Internal Factors	*Technological Readiness*		Tornatzky, Fleischer, and Chakrabarti (1990)	

	Managerial Innovativeness	4	Molla and Licker (2005), Tornatzky, Fleischer, and Chakrabarti (1990)	Adapted
	Organizational Readiness	4	Tornatzky, Fleischer, and Chakrabarti (1990)	Adapted
	Strategic Fit with Operations	4	Goodhue and Thompson (1995)	Adapted
	Ease of Support	4	Grandon and Pearson (2004)	Self-constructed
	Organizational Culture (Firm propensity to take the risk)	4	Tornatzky, Fleischer, and Chakrabarti (1990) Škerlavaj, Song, and Lee (2010)	Adapted
Firm External Factors	*Organization Partner Requirements*	5	Iacovou, Benbasat, and Dexter (1995) Dimaggio and Powell (1983)	Self-constructed
	Competitive Pressure	4	Rogers (1962) Soares-Aguiar and Palma-Dos-Reis (2008)	Self-constructed
	Needs of Customers	5	Hauser, Tellis, and Griffin (2006), Lin, Tan and Geng (2013)	Self-constructed
Societal Factors	*Government Championship*	7	Howell, Shea, and Higgins (2005)	Self-constructed
	Government Policy	4	Bajaj and Leonard (2004)	Self-constructed
	Government Regulation/ Laws	4	Bajaj and Leonard (2004)	Adapted
	Innovation Infrastructure	4	Tornatzky and Fleischer (1990)	Self-constructed
	Opinion Leadership	4	Rogers (1962)	Adapted
	Successive Government Commitment	4	Mathews (2012)	Self-constructed
Technology Characteristics	*Flexibility*	4	Rogers (1962)	Adapted
	Observability	4	Rogers (1962)	Adapted
	Complexity	4	Rogers (1962)	Adapted
	Relative Advantage	5	Rogers (1962)	Adapted

Appendix B Table 2 Correlation Matrix of all constructs

Constructs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1. Firm Level Adoption	**1.00**																									
2. Perceived Ease of Use	0.21	**1.00**																								
3. Perceived Usefulness	0.13	0.24	**1.00**																							
4. Perceived Indispens.	0.31	0.14	0.30	**1.00**																						
5. Perceived Soc. Influen.	0.19	0.22	0.71	0.40	**1.00**																					
6. Trial Feedback	0.00	0.03	0.41	0.34	0.64	**1.00**																				
7. Employee Self Interest	-0.06	0.22	0.64	0.32	0.73	0.46	**1.00**																			
8. Technological Readi.	0.06	-0.01	0.27	0.15	0.48	0.26	0.42	**1.00**																		
9. Managerial Innovati.	0.22	0.36	0.29	0.38	0.44	0.30	0.48	0.74	**1.00**																	
10. Organisational Read.	0.09	0.09	0.38	0.22	0.63	0.37	0.52	0.69	0.62	**1.00**																
11. Strategic Fit with Ops.	0.19	-0.01	0.38	0.60	0.59	0.27	0.56	0.67	0.58	0.74	**1.00**															
12. Ease of Support	0.07	0.14	0.50	0.01	0.53	0.37	0.48	0.71	0.50	0.69	0.59	**1.00**														
13. Org. Culture	0.05	0.19	0.14	0.33	0.56	0.31	0.44	0.72	0.65	0.74	0.66	0.44	**1.00**													
14. Org. Partner Req.	0.25	0.09	0.26	0.47	0.49	0.24	0.32	0.69	0.62	0.83	0.74	0.49	0.81	**1.00**												
15. Competitive Pressure	-0.12	0.02	0.32	0.54	0.50	0.30	0.52	0.61	0.50	0.59	0.65	0.31	0.76	0.75	**1.00**											
16. Needs of Customers	0.07	-0.02	0.45	0.41	0.67	0.35	0.61	0.81	0.62	0.71	0.75	0.62	0.70	0.74	0.78	**1.00**										
17. Government Champ.	0.09	0.10	0.60	0.43	0.66	0.51	0.62	0.45	0.52	0.67	0.74	0.63	0.50	0.49	0.50	0.51	**1.00**									
18. Government Policy	0.33	0.13	0.34	0.22	0.70	0.51	0.51	0.35	0.37	0.49	0.33	0.40	0.31	0.29	0.29	0.48	0.37	**1.00**								
19. Government Reg.	0.48	0.02	0.32	0.31	0.60	0.38	0.32	0.57	0.35	0.45	0.51	0.48	0.32	0.39	0.34	0.55	0.38	0.74	**1.00**							
20. Innovation Infrast.	0.37	0.09	0.36	0.05	0.49	0.26	0.20	0.35	0.23	0.23	0.20	0.36	0.11	0.16	0.18	0.34	0.17	0.76	0.75	**1.00**						
21. Opinion Leadership	0.30	0.28	0.45	0.24	0.67	0.38	0.61	0.50	0.57	0.54	0.39	0.38	0.49	0.45	0.48	0.55	0.37	0.80	0.59	0.71	**1.00**					
22. Succ Govt. Commit	0.47	0.19	0.40	0.02	0.47	0.33	0.35	0.44	0.41	0.25	0.28	0.41	0.21	0.11	0.09	0.19	0.47	0.52	0.67	0.64	0.60	**1.00**				
23. Flexibility	0.45	0.18	0.30	0.36	0.43	0.01	0.28	0.11	0.24	0.15	0.28	0.03	0.27	0.28	0.34	0.32	0.19	0.51	0.41	0.54	0.54	0.32	**1.00**			
24. Observability	0.36	0.39	0.28	0.39	0.68	0.40	0.41	0.31	0.50	0.32	0.39	0.22	0.43	0.24	0.27	0.37	0.42	0.65	0.63	0.54	0.53	0.53	0.63	**1.00**		
25. Complexity	0.31	0.44	0.19	0.29	0.45	0.37	0.22	0.12	0.44	0.26	0.12	0.16	0.27	0.20	0.23	0.21	0.32	0.62	0.44	0.54	0.54	0.37	0.41	0.61	**1.00**	
26. Relative Advantage	0.27	0.47	0.30	0.26	0.51	0.27	0.47	0.08	0.31	0.41	0.29	0.33	0.31	0.23	0.25	0.18	0.54	0.72	0.43	0.47	0.60	0.46	0.53	0.60	0.65	**1.00**