Is biometric authentication a contributor in deepening cashless market in African context? Customers' reaction

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Abstract: *Major part of African economy such as Nigerian economy has been experiencing high rate of adult financial exclusion, and poor usage of novel financial technologies. Several factors have been shown from developed nations to have significant effect on how customers use and adopt financial innovations. The study investigates the acceptance and use of fingerprint biometric authentication in an African context. This is critical because of the driving cashless policies of most African nations like Nigeria and the proliferation of different financial innovations to which a significant few have gained user traction. The paper is centered on advancing structural model to fit the African context of fingerprint authentication, and assess how customers' perception of its usefulness can have mediating influence on its adoption. Thus, how do customers perceive usefulness of fingerprint authentication in adopting the device when associated with other determinant factors? Cross-sectional design was adopted while adapted structured questionnaire was used to pool 311 responses using snowball sampling. Confirmatory factor analysis was carried out while structural equation modeling was used to prove the hypotheses. Convenience, perceived security, personal innovativeness, perceived usefulness and subjective norm are the key drivers of fingerprint biometric authentication in Africa. However, convenience is the key contributor in deepening the cashless market while perceived usefulness partially mediate behavioral intention. The predictive power of*

76% intention to use biometric authentication indicates inclusion of major factors that enables understanding of the implications while the mediation analysis portrays the value of such factors in deepening cashless market. Also it is one of scarce literature on deepening cashless market in African context through biometric authentication. Therefore, it is concluded that in African context of customer reaction to biometric authentication, convenience has paramount influence while customers significantly value usefulness as it mediates the relationship of other factors to the adoption of the innovation.

Keywords: *Consumer behaviour; Biometric authentication; Electronic financial transaction*

Introduction

The advent of e-commerce and electronic payment methods have been growing in volume and value in Nigeria following some key factors such as increasing consumer confidence in electronic channels. Technological innovations and their advancements play a significant part in transforming e-payment. Innovations in financial services have contributed immensely to these transformations with big-tech and fintech firms rapidly introducing other payment services. The Central Bank of Nigeria's (CBN) early introduction of transformative monetary policies has also enhanced its development. However, the level of penetration of these electronic financial innovations is poor in most African nations. In Nigeria, with over 200 million Nigerians, about 40% adult Nigerians are financially excluded. The problem is associated with concerns in data security and protection (Nigerian Communication Commission, 2021). Notably, the risk of fraud is a key security challenge on e-payment.

A huge amount of financial losses is attributed to automated teller machine (ATM) fraud (The Nilson Report, 2019). This occurs through shoulder surfing, use of stolen ATM cards, card jamming, and card swapping with shoulder surfing and stolen ATM cards being the most prevalent ones in Nigeria. This led to another setback in Nigeria's drive towards cashless society given that cash preference continued to dominate customers' choice of financial payment options. The progress recorded in some cases has come with other challenges. Extant literature shows that the increase in transaction processing speed and proliferation of e-payment channels came with more vectors for fraudulent transactions (Iloduba *et al.,* 2019).

In some cases in Nigeria there are reported cases of armed thieves moving around with point of sale (PoS) machines to compel customers to part with their money (Nelson, 2018). In this regard, the wide use of ATM PIN (personal identification number) as an authentication mechanism is not safer and secure.

Thus, as security threats have propelled the need for improvement on current methods (Ahmed *et al.,* 2015) innovation is rapidly driving evolution in e-payments to deliver better benefits to customers thereby making digital transformations to alter the financial transaction landscape. Biometric authentication is a viable solution to curtail the frightening increase in ATM and PoS fraud cases given the non-transferability of biometric data, its uniqueness to the individual (Iloduba *et al.,* 2019), and its ability to match the scan with the records on a database (Ashbourn, 2000). It is a special innovation designed to capture the physiological, behavioural, or both traits of an individual while analyzing these inputs to identify if the individual is genuine or maliciously using the system.

Biometric authentication can be in form of fingerprint, face recognition, hand geometry, iris, and voice but fingerprint is used more than others (German and Barber, 2016).

The system is safer, protected, easier to use, and comparably beneficial (Vijayaraj, and Jebamoses, 2015). The authors consider this to be significant

because of its potential in changing the customer payment dynamics about cashless transactions and encouraging uneducated population to get involved in electronic financial transactions. Secondly, it is considered by the authors to offer an avenue for the older population and female gender to get involved in safer financial transactions. Majority of the studies on biometric authentication are specifically focused on developed nations and few emerging economies where focus has been on narrative accounts of applications (Kolawole, 2020).

Its adoption and popularity is increasing (Buckley and Nurse, 2019) in the financial sector, information technology, government agencies and private agencies. This is because of its user-centered design that captures valid biometric traits, unique properties, and its performance reliability.

The biggest hurdle to its usage is user acceptance (Buckley & Nurse, 2019) which has been attributed to public perception issues and the possibility of reproducing the scanned fingerprint by criminals. However, It offers ease of transaction to customers, encourages customers' loyalty to banks, builds customer confidence, attracts the unbanked and delivers a smoother customer experience and fraud reduction.

Despite these benefits, concerns noted against it include the leak of biometric data arising from poor protection, vulnerability to spoofing, and poor identity management and security (Rosén *et al.,* 2021). In Nigeria, the adoption is very poor. Extant reports suggest this given is that the Nation is the 9th worse nation in its adoption. This poor adoption might arise from less or no value user perception; poor awareness level of its benefits, low innovativeness, resistance, and lack of information on its usefulness. Thus, the objective in this study is to assess how customers react to fingerprint authentication given recent developments in massive roll-out by Nigerian commercial banks. Secondly, the study intends to assess the mediating effect of perceived usefulness given that its importance has been overlooked in literature in determining the level of mediation on adoption. The contribution of the study is seen from two key angles. First, the study built on previous narrative studies on biometric authentication by estimating the effect of the variables on intention to use using questionnaire scales from e-payment innovations. Particularly, the results of the effect of personal innovativeness on intention to use are not unified in behavioural studies' literature (Singh *et al.,* 2020b).

Secondly, the mediating influence of perceived usefulness was estimated to understand how to bridge the gap on financial inclusion. As a result, the study proposed a two-level structural model by making modifications to TAM. In the first level, perceived ease of use, subjective norm, perceived security, and personal innovativeness were estimated. In the second level, subjective norm, perceived security, personal innovativeness, convenience, and perceived usefulness were estimated.

Limitation of study

The study is limited to 311 adults in South East region of Nigeria. The intent is to adopt technology acceptance model with extensions and discover the mediating effect of perceived usefulness on relationships. As it is a cross sectional survey, it is limited to 4-5 months survey given paucity of fund.

Literature Review

Generally, studies have viewed biometric authentication from different angles. Al-Rahawe et al (2019) considered biometric authentication frameworks, its evolution and challenges to proffer a solution for its improvement. Blancho-Gonzalo et al., (2019) examined the interaction with biometric systems, environmental challenges that impact its usage and recommended a solution for future developments. Rosén et al., (2021) conducted a quantitative study on consumers' intention to biometric payment card with the aim of understanding business dimension of its integration. In using TAM, the study concluded that perceived usefulness and perceived ease of use have no influence on behavioural intention

while attitude and trust are determinant factors. In relation to biometric use in airports Kabir (2021) adopted theory of planned behaviour, and suggests from the findings that attitude and subjective norm are key determinants on intention while behavioural control has not significant effect. Seyal and Turner (2013) assessed executives' use of biometrics by anchoring on the theory of planned behaviour. Subjective norm and attitude was concluded as key determinant in adopting the innovation. In applying thematic analysis, Buckley and Nurse (2019) assessed the language of biometrics and provided understanding about individuals aligning to biometrics they are familiar with while ignoring ones they lack knowledge about. In this regard, the present study adopts technological acceptance model with extensions (see figure 1). The model as propounded by Davis (1989) considers attitude, perceived usefulness and ease of use to be the critical factors that influence intention.

Perceived Ease of use (PEoU)

PEoU is about the consumer's perception of simplicity in using a technology (Oloveze *et al.,* 2021). In this study, it is the user's perception of simplicity in using fingerprint to conduct financial transactions. PEoU plays a dual effect on attitude and usefulness (Davis, 1989). It influences attitude and intention to use biometrics (Rosén *et al.,* 2021) and impacts usefulness through improved performance particularly when the improvement in PEoU is instrumental (Liébana-Cabanillas *et al.,* 2014). This connection is only supported where there is a provision of a useful guide on its usage, convenience, and usefulness. PEoU is a significant predictor of perceived usefulness in several e-payment studies such as location-based services (Hossain *et al.,* 2017), NFC technology (Ramos-de-Luna *et al.,* 2016a) and online shopping (Oloveze *et al.,* 2022). Thus the authors propose:

Hypothesis 1: Perceived ease of use positively influence perception of usefulness to fingerprint biometric authentication

Personal Innovativeness (PI)

Personal innovativeness is a personality trait (Svendsen *et al.,* 2013) that Praveena and Thomas, (2014) refer to as an individual's willingness to have an experience of a new thing. It deals with the extent a person adopts a new idea freely and earlier compared with others (Singh *et al.,* 2020b). In this study, it is an individual's proclivity to adapt to biometric innovations and try something new about fingerprint biometric authentication. Essentially, individuals with innovative traits tend to positively respond to innovations than ones without the trait (Xu and Du, 2018) though the level of the innovativeness is dependent on the type of innovation (Singh *et al.,* 2020b) and the fast rate that consumers embrace innovation (Bozkurt and Gligor, 2019). Thus, as consumers embrace innovation faster, personal innovativeness increases. The fast rate depends on the usefulness attached to the novel innovation. In extant literature, it is considered as a moderator (Singh *et al.,* 2021b) and a predictor of intention (Oliveira *et al.,* 2016). As a factor it can cause differences in reaction to an innovation but depends on the type of innovation (Singh *et al.,* 2020a) because when innovativeness is higher there is more positive attitude to adopt the innovation (Xu and Du, 2018). However, discordant results show that it is a predictor of behavioural intention in some studies (Oliveira *et al.,* 2016) and not a significant predictor of intention or a moderator in others (Singh *et al.,* 2020b). The authors propose:

Hypothesis 2: Personal innovativeness positively influence perceived usefulness

Hypothesis 3: Personal innovativeness positively influence intention to use fingerprint biometric authentication

Subjective Norm (SN)

Subjective norm deals with social pressures from friends, relatives and other individual's referents that make them behave in a certain way (Ajzen, 1991). Theory of planned behaviour and theory of reasoned action considers that besides attitude,

subjective standards of an individual is important in determining behavioural intention because it comprises of an individual's values of conduct and standards. In this study, uncertainties in the use of the innovation may prompt an individual to seek the opinion of others who might have experience on the innovation or with related innovation. The construct consists of the user's belief of referent's opinion, and motivation to behave according to referents' opinion. Its importance is further highlighted by its inclusion in several studies dealing with online shopping (Oloveze *et al.,* 2022), and P2P m-payment (Kalinic *et al.,* 2019). It is associated with perceived usefulness of m-commerce studies (Liébana-Cabanillas *et al.,* 2018) and significantly predicts behavioural intention (Kalinic *et al.,* 2019). The authors propose:

Hypothesis 4: Subjective norm positively influence perceived usefulness

Hypothesis 5: Subjective norm positively influence intention to use fingerprint biometric authentication

Perceived Security (PS)

Perceived security deals with privacy of personnel data, and secure transaction (Ramos-de-Luna *et al.,* 2019). It is about the risk of losing vital information that eventually causes loss of finance (Liébana-Cabanillas *et al.,* 2018). In this study, it deals with the risk of losing biometric data that will cause financial losses. User concerns of security are buttressed from its capacity to deter behavioural intentions (Ramos-de-Luna *et al.,* 2019). Users tend to assess the internal and external consequence of use to determine the benefit or risk of usage (Ramos de Luna *et al.,* 2016b). Thus, it influences behavioural intention and how the utility is perceived (Ramos-de-Luna *et al.,* 2016b). Several studies have researched the security dimension of innovations. For instance, security has been used to ascertain the perceived usefulness of an innovation (Ramos-de-Luna *et al.,* 2016b) and user intention (Liébana-Cabanillas *et al.,* 2018). It is a significant predictor of intention to use m-payment (Oliveira *et al.,* 2016), but does not significantly predict user intention in other studies (Ramos-de-Luna *et al.,* 2019). Therefore the authors propose:

Hypothesis 6: Perceived security positively influence perceived usefulness

Hypothesis 7: Perceived security positively influence intention to use fingerprint biometric authentication

Convenience (Con)

Convenience is a blend of time and place utility (Pal *et al.,* 2015). Consumers consider it important in transacting in a virtual marketplace as it is vital in consumers' choice of payment channel (Chen and Nath, 2008). Convenience is a combination of time and effort spent (Copeland, 1923). It is an important factor in accepting and using innovation given the associated elements of speed and ease (Duarte *et al.,* 2018). It is a multidimensional construct comprising of access, search, evaluation, transaction, and possession/ post-possession convenience (Shankar and Rishi, 2020). In fingerprint biometric authentication, speed and ease, time savings, and less demand of effort are necessary attributes of convenience. It can impact consumers' perception of value (Singh *et al.,* 2020a). Extant literature shows a direct and positive relationship between convenience and intention to use (Shankar and Rishi, 2020) and an indirect effect on behavioural intention (Singh *et al.,* 2020a). Thus the authors propose:

Hypothesis 8: Convenience positively influence intention to use fingerprint biometric authentication

Perceived Usefulness (PU)

Perceived usefulness is the degree of an individual's believability that new technology will enhance performance (Davis, 1989). In the context of biometrics, it is time-saving, improved user experience, convenience, and better security (Rosén *et al.,* 2021). Its importance is highlighted by its inclusion in several studies related to

electronic financial innovations. Empirically, it is one of the most significant determinants of m-payment acceptance (Liébana-Cabanillas *et al.,* 2018), satisfaction of m-commerce (Kalinic *et al.,* 2021), and intention to adopt m-wallet services (Singh *et al.,* 2020b). However, it has no significant effect in others (Muñoz-Leiva *et al.,* 2017). All technologies do not have the same consumer acceptance because they are not the same (Ramos-de-Luna *et al.,* 2019). Therefore the authors propose:

Hypothesis 9: Perceived usefulness positively influence intention to use fingerprint biometric authentication

Mediating effect of perceived usefulness

PU is estimated more as a predictor than mediator in several studies (Muñoz-Leiva *et al.,* 2017). These approach has been adopted in online shopping (Oloveze et al., 2022), mobile payment (Liébana-Cabanillas *et al.,* 2018), and m-wallet (Singh *et al.,* 2020b). In this study, the mediation aspect is considered to provide a better understanding of the role of perceived usefulness on fingerprint biometric authentication. In this regard,

R1: How does perceived usefulness mediates the effect of subjective norm on intention to use fingerprint biometric authentication

R2: What is the mediating influence of perceived usefulness on the relationship between perceived security and intention to use fingerprint biometric authentication

R3: How does perceived usefulness mediate the effect of personal innovativeness on intention to use fingerprint biometric authentication

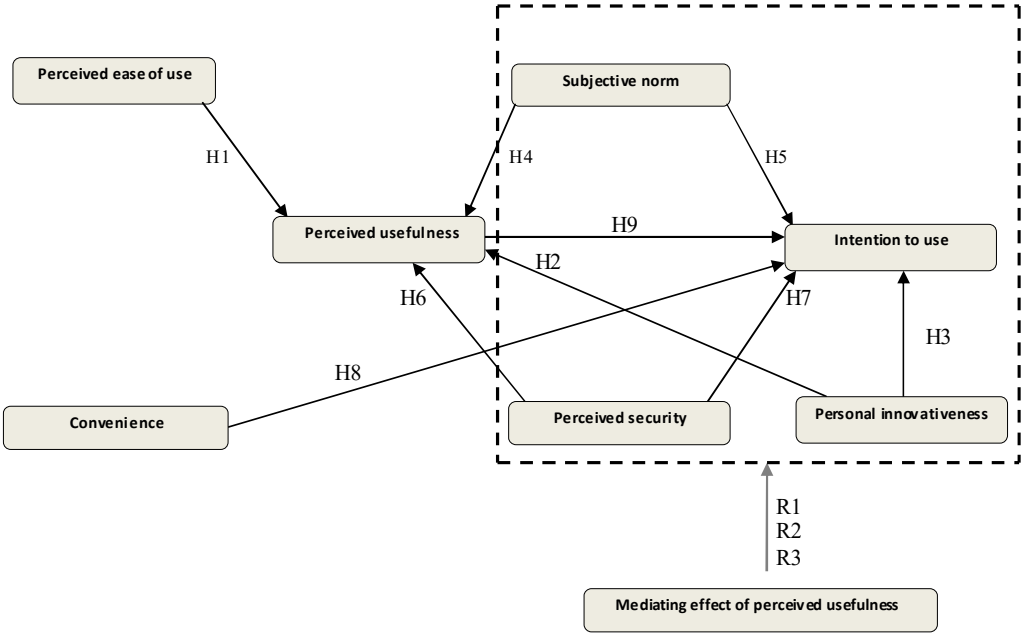


Figure 1: Conceptual model

Source: Self-developed from STATA

Research Method

To examine the proposed conceptual model, a survey approach was undertaken. Attention was focused on customers with bank accounts.

Measurement Development

Firstly, questionnaire items were adapted from related studies on e-payment innovations and indicated as follows: Perceived ease of use –Lara-Rubio *et al.,* (2020); Perceived usefulness –

Ramos de Luna *et al.,* (2016); Subjective norm – Lara-Rubio *et al.,* (2020); Perceived security – Ramos de Luna *et al.,* (2016ab); Personal innovativeness –Singh *et al.,* (2020ab); Convenience –Singh *et al.,* (2020b); Intention to use –Lara-Rubio *et al.,* (2020)

Secondly, the questionnaire was subjected to a preliminary and reliability test using face and content reliability. This is because of the context of the study and the need to ascertain the internal consistency of items and the suitability of measurement scales. A group of eight experts reviewed the questionnaire for wording appropriateness, measurement scales coverage, and methodology used. 4 items for each construct were used to measure perceived ease of use, subjective norm, personal innovativeness, convenience, and intention to use. 3 items for each construct were used to measure perceived usefulness and perceived security. A blend of snowball and convenience sampling was used to collect the data because of the non-existence of the sampling frame and the unknown nature of the population as at the time of the study.

Thirdly, the questionnaire was administered online through email and WhatsApp with the link made available for an invitation to fill out the form. The questionnaire was structured in four sections. The first section contains the demographic information of the user. The second section contains a filter question to screen out those that have used the innovation. The third section involved the adapted constructs. 7-point Likert scale was used for the constructs where 1 represents strongly disagree and 7 represents strongly agree. At the end of data collection, 347 forms were collected. 36 irrelevant forms were screened out. This represents 10%. The demographic results show that 2.7% were below 20 years, 40.5% were within 21-30 years, 43.7% were within 31-40 years, 9.6% were within 41-50 years while 3.5% were above 50 years. 60.8% were male while 39.2% were female. 7.7% has a college/WAEC certificate as the highest educational qualification, 1.6% has a national diploma, 58.2% has a first degree/B.Sc, 21.5% has a second degree/Masters, while 10.9% has a third degree/Doctorate. On the level of knowledge of fingerprint biometrics on ATM, 10.3% of 347 respondents have heard of it and used it at least once, 43.1% have heard of it but have not tried it while 46.6% have not heard of it. Thus, 89.7% (311) have not tried it because they do not have appropriate knowledge of it. This represents the valid responses that were examined.

Analysis

Data analysis was carried out through IBM SPSS 23 and STATA 15. Herman's one-factor test was used to check for common method bias (CMB). The items were adjusted to a single factor. It produced 48.79%. This is within the threshold of 50% thus indicating no existence of CMB (Kalinic *et al.,* 2019). Cronbach's alpha and composite reliability were used to check the reliability while confirmatory factor analysis was used to check the validity and fit indices of the model. Structural equation model (SEM) was used to test hypotheses.

Reliability and validity analysis

The test of reliability shows that the Cronbach's alpha (CA) coefficient of each of the constructs exceeded the minimum threshold of 0.70. This satisfies the reliability criteria (Verkijika 2018). Composite reliability (CR) scores of the constructs were more than 0.7 recommended in literature (Fornell and Larcker, 1981). Convergent validity carried out through average variance extracted (AVE) indicates that all the values were above the recommended minimum score of 0.5 (Hair *et al.,* 2014). All the confirmatory loadings were above 0.60. See Table 1. The fit of the conceptual model indicates that it fits the data (See Table 2). The values were within the threshold.

Table 1: Measurement Model

Item	Factorial loads
Perceived ease of use (CA=.881; CR=.920; AVE=.74; Mean=5.50; SD=1.34)	
Interacting with fingerprint biometric authentication does not require great effort	.841
Interacting with fingerprintbiometric authentication is straightforward	.871
It is easy to access fingerprint biometric authentication and perform my transactions	.880
In general it is easy to use fingerprint biometric authentication for transactions	.852
Perceived usefulness (CA=.851; CR=.776; AVE=.54; Mean=5.58; SD=1.30)	
Fingerprint biometric authentication is useful in quick transactions	.819
Using it makes it easier to handle cash withdrawal and payment	.753
In general using fingerprint biometric authentication could be useful forme	.617
Subjective norm (CA=.881; CR=.906; AVE=.709; Mean=4.95; SD=1.39)	
The people whose opinion I value would approve of me using fingerprint biometric authentication	.812
Most of the people I have in mind think that I should use fingerprint biometric authentication	.915
They expect me to use fingerprint biometric authentication	.872
The people who are close to me would agree with me in using fingerprint biometricauthentication	.761
Perceived security (CA=.664; CR=.855; AVE=.513; Mean=5.69; SD=1.29)	
Fingerprint biometric authentication is more secure than PIN and use of cash transactions	.664
I would like that the fingerprint biometric authentication is safe for my financial transactions	.747
Fingerprint biometric authentication reduces threat to my privacy	.734
Personal innovativeness (CA=.888; CR=.900; AVE=.694; Mean=5.79; SD=1.22)	
I will try fingerprint biometric authentication if I hear about it	.778
I will use fingerprint biometric authentication if see it	.881
I like to experiment with new innovations	.774
I am ready to try out fingerprint biometric authentication	.892
Convenience (CA=.868; CR=.852; AVE=.590; Mean=5.80; SD=1.16)	
Fingerprint biometric authentication will allow me ease of access to my account whenever I choose	.821
Using it will allow me access my account at my convenient time	.808
I value the ability to use it to access my account faster	.745
I like the ability to access my account for transaction without the need for much effort	.692
Intention to use (CA=.929; CR=.883; AVE=.654; Mean=5.87; SD=1.23)	
I will use fingerprint biometric authentication when the opportunity arises	.842
I am likely to use fingerprint biometricauthentication for transactions in the near future	.855
I am open to using fingerprint biometric authentication in the near future	.778
I intend to use fingerprint biometric authentication when the opportunity arises	.756

Cronbach Alpha = CA; Composite reliability = CR; Average variance extracted = AVE; SD = Standard Deviation

Source: Self-developed from SPSS output

Table 2: Model fit indices

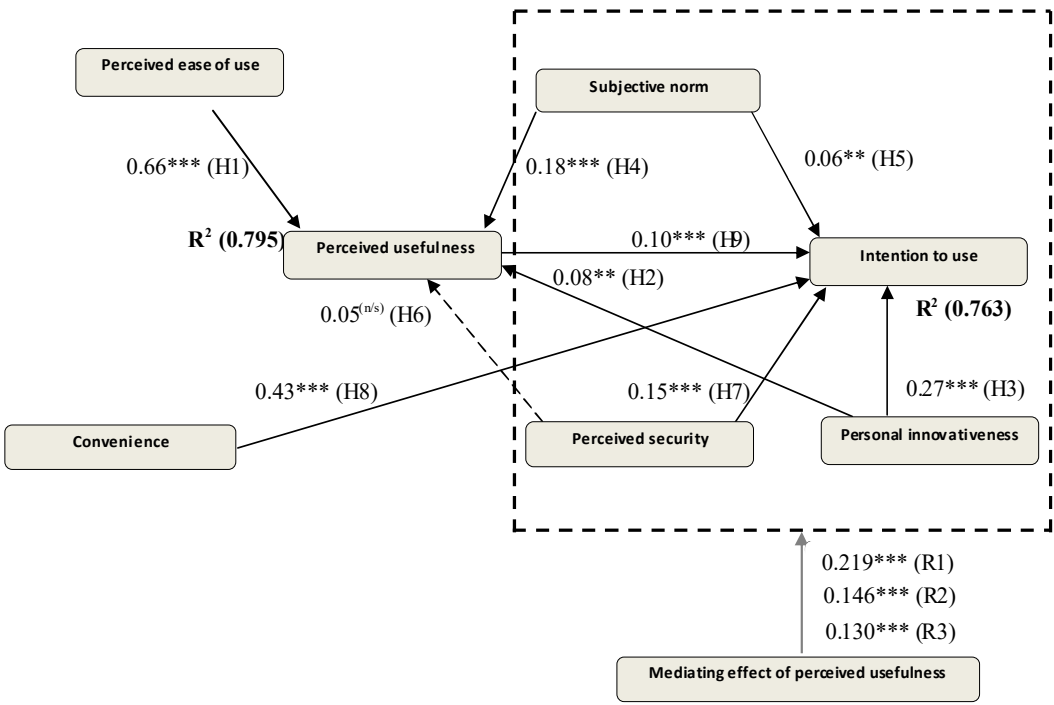
Fit indices	Recommended value	Value in the model	Reference
$\ddot{\kappa}^{2/df}$	<5	6.025	Bentler and Paul (1996)
RMSEA	<0.08	0.080	Hu and Bentler (1999)
Pclose	>0.05	0.181	
CFI	>0.90	0.995	Bentler and Paul (1996)
TLI	<0.90	0.973	Schumaker and Lomax (2016)
SRMR	<0.08	0.009	
R^2(PU)		0.795	
R^2(INT)		0.763	
Overall R^2		0.896	

Notes: RMSEA = Root mean squared error of approximation. CFI = Comparative fit index. TLI = Tucker-Lewis index. SRMR = Standardized root mean squared residual. PU = Perceived Usefulness. INT = Intention to use fingerptint biometric authentication

Source: Self-developed from STATA output

Path analysis

SEM was used to prove the proposed hypotheses. All the proposed paths were supported except the path of PS'!PU. H1 which proposed a direct effect of perceived ease of use on perceived usefulness of fingerprint biometric authentication was confirmed (â=0.659; pd"0.000) which corroborates previous studies (Liébana-Cabanillas *et al.,* 2018). H2 was confirmed (â=0.081; pd"0.071) which is contrary to previous studies (Ramos-de-Luna *et al.,* 2016b). H3 was confirmed (â=0.274; pd"0.000) which is in line with Singh *et al.,* (2020b) on continued intention but contrary with others (Kalinic *et al.,* 2019). H4 was confirmed (â=0.179; pd"0.071) which corroborates earlier studies (Liébana-Cabanillas *et al.,* 2018) but not confirmed in others (Ramos-de-Luna *et al.,* 2016b). H5 was confirmed (â=0.060; pd"0.087) which is in line with extant studies (Kalinic *et al.,* 2019). H6 was not confirmed (â=0.054; p=0.225) which is in line with related studies (Ramos-de-Luna *et al.,* 2016b). H7 was confirmed (â=0.149; pd"0.000) which supports findings of related studies (Ramos-de-Luna *et al.,* 2016b; Liébana-Cabanillas *et al.,* 2018) but not for QR payment system (Ramos-de-Luna *et al.,* 2019). H8 was confirmed (â=0.491; pd"0.000) and by this result convenience is the most significant driver of fingerprint biometric authentication. The result is in support of similar studies (Shankar and Rishi, 2020). H9 is confirmed (â=0.099; pd"0.008) just as in related studies (Oloveze *et al.,* 2022; Ramos de Luna *et al.,* 2019). (See figure 2 and table 3).



***p value≤ 0.001 ** p value ≤ 0.10, n/s = not significant

Figure 2: Result of conceptual model

Source: Self-developed from STATA

Table 3 : Testing of hypotheses and mediation analysis using medsem

Hypotheses	Std. estimates	Std. error	p-value	Result
H1: Perceived ease of use→Perceived usefulness	.659	.031	0.000	Supported
H2: Personal innovativeness→Perceived usefulness	.081	.045	0.071	Supported
H3: Personal innovativeness→Intention to use	.274	.047	0.000	Supported
H4: Subjective norm→Perceived usefulness	.179	.038	0.000	Supported
H5: Subjective norm→ Intention to use	.060	.035	0.087	Supported
H6: Perceived security→Perceived usefulness	.054	.045	0.225	Reject
H7: Perceived security→ Intention to use	.149	.042	0.000	Supported
H8: Convenience→ Intention to use	.427	.047	0.000	Supported
H9: Perceived usefulness→ Intention to use	.099	.037	0.008	Supported

Variable	Estimates	Delta	Sobel	Monte Carlo	Result
Subjective norm (X)	Indirect effect	0.219	0.219	0.220	Partial
Perceived usefulness (M)	Standard error	0.033	0.033	0.033	mediation
Intention to use (Y)	z-value	6.718	6.718	6.713	supported
	p-value	0.000	0.000	0.000	
	Confidence interval	0.155, 0.283	0.155, 0.283	0.153, 0.282	
	Baron & Kenny approach				
	X->M	B=0.541***			
	M->Y	B=0.405***			
	X->Y	B=0.238***			
	RIT	(0.219/0.457) = 0.480			
	RID	(0.219/0.238) = 0.923			
Perceived security (X)	Indirect effect	0.146	0.146	0.147	Partial
Perceived usefulness (M)	Standard error	0.025	0.025	0.025	mediation
Intention to use (Y)	z-value	5.874	5.786	5.863	supported
	p-value	0.000	0.000	0.000	
	Confidence interval	0.097, 0.195	0.097, 0.195	0.096, 0.194	
	Baron & Kenny approach				
	X->M	B=0.511***			
	M->Y	B=0.286***			
	X->Y	B=0.535***			
	RIT	(0.146, 0.681) = 0.215			
	RID	(0.146, 0.535) = 0.273			
Personal innovative.(X)	Indirect effect	0.130	0.130	0.130	Partial
Perceived usefulness (M)	Standard error	0.023	0.023	0.023	mediation
Intention to use (Y)	z-value	5.698	5.698	5.692	supported
	p-value	0.000	0.000	0.000	
	Confidence interval	0.085, 0.174	0.085, 0.174	0.084, 0.174	
	Baron & Kenny approach				
	X->M	B=0.534***			
	M->Y	B=0.243***			
	X->Y	B=0.662***			
	RIT	(0.130/0.792) = 0.164			
	RID	(0.130/ 0.662) = 0.196			

Source: Self-developed. ***p value d" 0.001, RIT -Indirect effect/total effect), RID – indirect effect/direct effect

Direct and indirect effect analysis

Sobel test was used to test the mediation effect of perceived usefulness. The result confirmed R1, (Z=6.718, indirect effect =0.219, pd"0.000), R2 (Z=5.786, indirect effect =0.146, pd"0.000) and R3 (Z=5.698, indirect effect =0.130, pd"0.000). See illustration on table 3 and figure 2

Discussion and Conclusion

The focus of the study was to assess the factors that determine user acceptance of fingerprint biometric authentication as a way of deepening the cashless market. The predictive power of the model is 0.896 which is higher than several models structured around TAM on e-payment technology (Ramos-de-Luna *et al.,* 2016b). Particularly, the R^2 value (0.795) for perceived usefulness is strong thus indicating a high percentage of variability through the endogenous

variables. R^2 value (0.763) for intention to use biometric authentication is strong thus indicating a strong explanatory power of the independent variables.

Generally, in the order of significant influence and importance, convenience, personal innovativeness, perceived security, perceived usefulness, and subjective norm are significant drivers of intention to use biometric authentication. The high predictive power of convenience indicates it has the most significant influence on fingerprint biometric authentication. In this regard, there is a logical understanding for the class of consumers seeking ease, speed, timeliness, and lesser-effort-spent to resort to the use of this e-payment system. This is more pronounced when the security dimension is factored in given the predictive significance of perceived security. In related studies, Singh *et al.,* (2020a) indicated its indirect effect on intention while Shankar and Rishi (2020) showed a significant direct effect of some of its components (access, transaction, and possession/post-possession convenience) on adoption intention.

The result of the mediation analysis using the Medsem approach on STATA 15 indicated that perceived usefulness has significant partial mediation on the relationships between the variables. The results of the Sobel tests for the respectively tested mediation were significant. When the results of Baron and Kenny on indirect effect/total effect (RIT) were considered, the relationship between subjective norm and intention to use shows that perceived usefulness mediates about 48% of subjective norm's influence on intention to use fingerprint biometric authentication. With the result of indirect effect/direct effect (RID), the mediated effect is about nine (9) times as large as the direct effect of subjective norm on intention to use. The mediation effect of perceived usefulness is also shown to mediate about 21% of perceived security's effect on intention to use going by the values of RIT. With RID the mediated effect is about three (3) times as large as perceived security's influence on intention to use fingerprint biometric authentication. Lastly, on grounds of RIT values, perceived usefulness mediates 16% personal innovativeness' influence on intention to use fingerprint biometric authentication. With RID values, the size of the mediation effect of perceived usefulness is two (2) times as large as the direct influence of personal innovativeness on intention to use fingerprint authentication. Generally, perceived usefulness significantly mediates the effect that subjective norm, perceived security, and personal innovativeness has on fingerprint biometric authentication.

Limitations

A key limitation is the use of cross-sectional study. The disadvantage of a cross-sectional study can be offset with a longitudinal study which can provide better insight on the predictors of intention to use fingerprint biometric authentication. Convenience was shown to be the most significant predictor of fingerprint biometric authentication. Thus, it would be needful to consider different dimensions of convenience to discover the main dimension of convenience that drives this type of innovation. Lastly, non-probabilistic sampling was used in this study. Future studies can adopt a probabilistic sampling approach because it will positively impact external validity.

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