

Evaluation and performance comparison of a model for adoption of biometrics in online banking

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Abstract

The research started by developing a model for measuring the customers' acceptance of biometrics adoption in online banking in Kuwait. Self-administered questionnaires were distributed through *SurveyMonkey.com* platform. A total of 500 invitations were sent and 302 valid responses were received. The data was analysed using *SPSS* software tool, version 22. Analyses such as descriptive, correlation, regression, t-test and one-way ANOVA were conducted on the collected data to test their relationships and significance. The results revealed that self-efficacy, perceived behavioural control, reliability, appearance, support, content, safety and privacy are important parameters that need to be *carefully* addressed by the bank management while considering adoption of Biometrics in online banking in Kuwait. Bank management need also to ensure that the *intended* biometric system is easy to use, that it provides the expected usefulness, and that it ensures high level of convenience and that it earns (*secures*) customers' trust and satisfaction.

Keywords: Online banking; biometrics; biometrics adoption models; biometrics in banking in Kuwait; technology adoption.

1. Introduction

The topic of online banking together with its associated attributes, e.g. trust and security has been vastly reported in the literature (Herman Mandari, Daniel Koloseni, 2016; Popoola. N. F., 2013; Dauda, s. Y, *et al.*, 2016; Rodrigo F. *et al.*, 2016; Tiago Oliveira *et al.*, 2016; Tiago Oliveira, *et al.*, 2016; Goncalo Baptista, *et al.*, 2015; Adesina A, *et al.*, 2010; Azam, A., *et al.*, 2012; Tiago Olivera, *et al.*, 2014; Oghenerukevbe, A. E, 2008; French, 2012; Normalini, M. K, *et al.*, 2012; Peotta, L. M, *et al.*, 2011). In addition, a number of literature articles were presented on various theories used in technology adoption, e.g. the theory of planned behaviour (Doll, J. & Ajzen, I., 1992), the theory of reasoned action (Zhang, L., *et al.*, 2012), the infusion-diffusion theory (Montazemi, A. *et al.*, 2015; Chiou, J.-S. & Shen, C.-C., 2012), and the theory of perceived risk (Aghekyan, M., 2009; Bhatnagar, A. & Ghose, S, 2004). Two different technology adoption models have also been presented in the literature, e.g. the technology acceptance model (Davis, F. 1989; Venkatesh, V. *et al.*, 2000; Yousafzai, S.

Y *et al.*, 2007) and Unified Theory of Acceptance and Use of technology (Venkatesh, V., *et al.*, 2003; Yeow, P., *et al.*, 2008; Tan, B. J. P., 2013).

The importance of leading-edge information technology (IT) solutions that could help business gain a competitive advantage has been discussed in (Jain. K. A., *et al.*, 2006; Clarke, N. L *et al.*, 2007; Condon, R. 2007). The need for stronger customer authentication in e-commerce environments, such as online banking, has developed into a necessary means of endorsing customer safety, confidence, and acceptance (Venkatraman. S., *et al.*, 2008; Williamson, G. D., 2006; Song, O.T. *et al.*, 2007). Biometrics technology could play a major role in protecting resources and thus keeping a safe banking environment. Technology adoption is the apparent choice for a new invention or innovation (Dauda, s. Y & Lee, J. 2015). Service industry and the banking sector are the most beneficiary in adopting new technology in interacting with their customers. Banks should always seek developing

new alternate delivery channels with the main the emphasis being improving customers' expectations and ensuring customer loyalty (George, A., & Kumar, G. S. G., 2014) . We summarize in Table (1) the above findings together with our own remarks. We use statistical modelling (Barakat, *et al.*, 2014 & Jadid, M.N., 2001)

In this paper, we propose a model for adoption of biometrics in online banking systems. We also provide an evaluation and performance comparison

of the model with those provided by existing models in the literature.

2. Proposed model and hypotheses

Figure 1 presents the proposed model. The proposed research model has been inspired by a careful study of the pros and cons of the following existing models:

- (a) The Technology Adoption Model (TAM) (Davis *et al.*.,1989) .

Table 1. Summary of biometrics models

	Reference	Remarks
ATM Banking	Dauda, S. <i>et al.</i> , 2015	1. Study reviewed customers' perception of future online services. 2. Our research model inspired various factors of the model introduced in this paper.
	Rashed A., <i>et al.</i> , 2010	The study presents some interesting factors that can be considered for understanding customer perception of biometrics.
	Onyesolu, M.O, <i>et al.</i> , 2012	1. This article provides useful information on the different types of biometrics leading to the recommendation of fingerprint. 2. The article Lacks discussion of various models in the adoption of this new technology.
Mobile Banking	Sinha K.A. 2013	1. This article provides general information on the use of biometrics. 2. The findings in the article provide a report on the actual use of mobile platforms in financial transactions. 3. The report emphasizes the need for increased security in mobile financial transactions.
	Raina K. V, 2011	This article provides detailed process that should be useful for practitioners in the implementation and use of biometrics during payment process.
	Tsai Yuan Cheng <i>et.al.</i> 2012	The findings of this study should be useful for banks while implementing biometrics in mobile banking platforms.
Internet Banking	Montazemi A. <i>et al.</i> , 2015	1. This study provides good literature and empirical support for online banking adoption. 2. The factors identified by the authors should be important in determining customers' perception and actual usage of online banking.
	TassaBehjia R. <i>et al.</i> , 2012	The information in this study is useful towards understanding the use of different types of biometrics such as facial recognition, fingerprint, iris, and voice recognition.
	Venkatram-an S. <i>et al.</i> , 2008	The information provided in this study is good towards implementing biometrics as additional level of security.

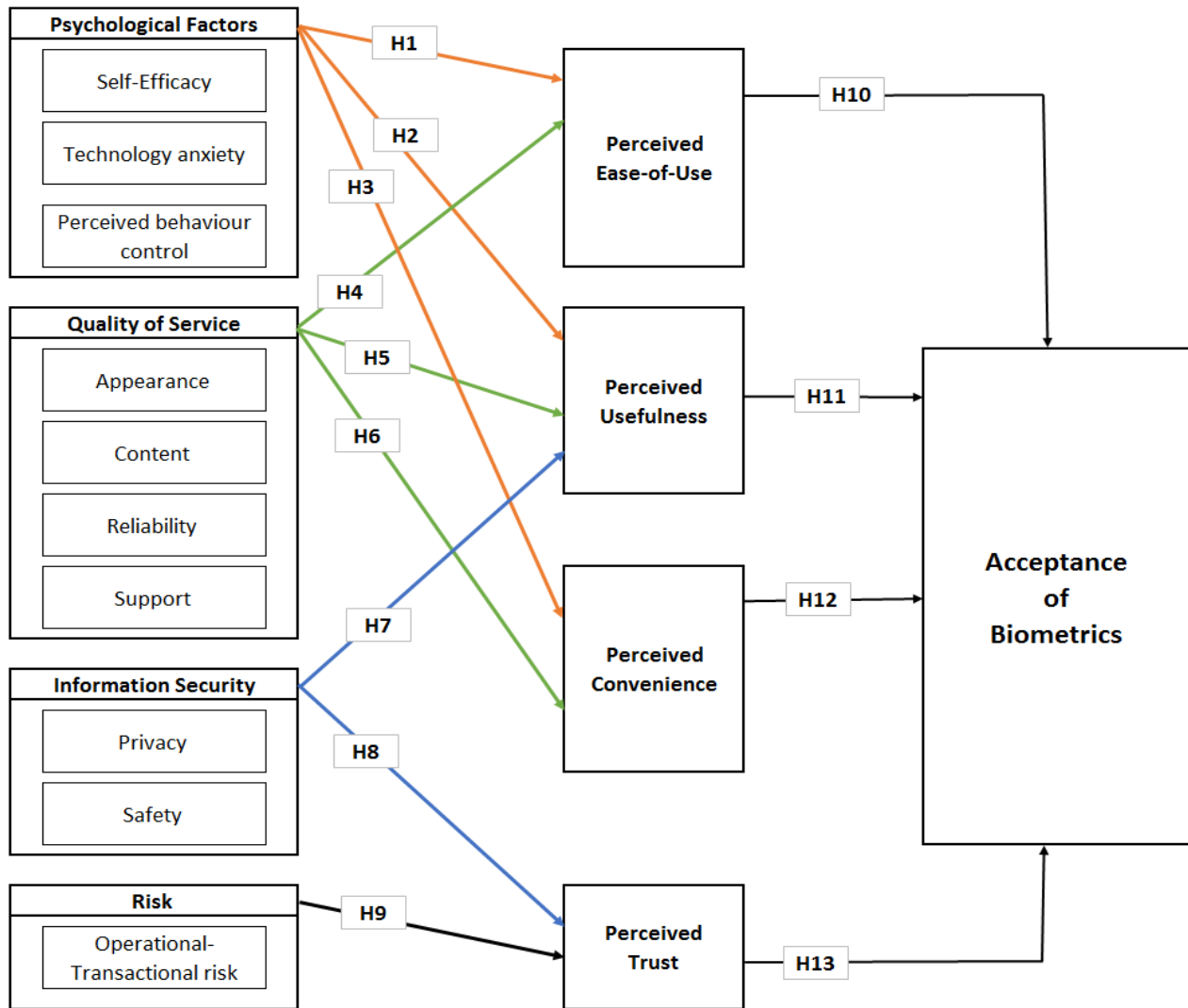


Fig. 1. Proposed Research Model.

- (b) The model developed by Santos (Santos S, 2003).
- (c) The model developed by Shen (Shena, Y-C, *et al.*, 2010).
- (d) The model developed by Mermud (Mermud Y. A, 2011).
- (e) The model developed by Miltgen (Miltgen H. T, *et al.*, 2013).

The main components of those models are presented in Table 2.

The proposed model is a 3-tier model: The external factors (independent variables), the dependent variables, and the outcome (biometrics acceptance).

The components of the three levels of the model and a detailed description of each level are presented in Table 3, 4, and 5, respectively.

It should be noted that out of the 15 features, there are two features that were not considered by any of the six existing models (Appearance and Support). Also, out of the remaining 13 features, there are six features, (Technology Anxiety, Perceived behaviour control, Content, Reliability, Privacy, and Perceived ease of use) which were considered by only one of the considered six models. It should also be noted that among the six existing models, the maximum number of features that were

considered by any of those models is seven features (46.7%) in case of the SH model (Shena Y.C., *et al*, 2010). This shows the degree of comprehensiveness and distinction of the proposed model.

In the proposed model, we hypothesize the followings:

- **H1:** The impact of perceived ease-of-use (PEOU) of biometrics on online banking will be positive.
- **H2:** The impact of perceived usefulness of biometrics on online banking will be positive.
- **H3:** The impact of perceived convenience of biometrics on online banking will be positive.
- **H4:** The impact of perceived ease-of-use of biometrics on online banking will be positive.
- **H5:** The impact of perceived usefulness of biometrics on online banking will be positive.
- **H6:** The impact of perceived convenience of biometrics on online banking will be positive.
- **H7:** The impact of perceived usefulness of biometrics on online banking will be positive.
- **H8:** The impact of perceived trust of biometrics on online banking will be positive.

- **H7:** The impact of perceived usefulness of biometrics on online banking will be positive.
- **H9:** The impact of operational-transactional risk will be negative.
- **H10:** Online banking customers who are concerned about the perceived ease-of-use of online banking are more likely to accept the use of biometrics in online banking.
- **H11:** Online banking customers who are concerned about the perceived usefulness of online banking are more likely to accept the use of biometrics in online banking.
- **H12:** Online banking customers who focus on the perceived convenience of online banking are more likely to accept the use of biometrics in online banking.
- **H13:** Online banking customers who are concerned about the perceived trust in online banking are more likely to accept the use of biometrics in online banking.

Table 6, shows the model components cross-listed against those of the six presented existing models. Table 7 summaries the hypotheses as expressed in the research model.

Table 2. Component listing of TAM, UTAUT, Santos, Shen, Mermod, Miltgen models.

#	TAM (Davis <i>et al.</i> 1989)	#	UTAUT (Venkatesh V. <i>et al.</i> , 2003)	#	Shen (Shena ,Y-C, <i>et al.</i> , 2010)
TA-1	Perceived usefulness	UT-1	Performance expectancy	SH-1	Self-efficacy
TA-2	Perceived ease of use	UT-2	Effort expectancy	SH-2	Expertise
TA-3	Attitude toward using	UT-3	Social influence	SH-3	Technology anxiety
TA-4	Behavioural intention	UT-4	Facilitation conditions	SH-4	Perceived behaviour Control
TA-5	Actual use	UT-5	Behaviour intention and use	SH-5	Trust in telecom supplier
#	Santos (Santos S, 2003)	#	Mermod (Mermod Y. A, 2011)	#	Miltgen (Miltgen H. T, <i>et al.</i> , 2013) .
SA-1	Ease of use	ME-1	Strategic risk	SH-6	Behavioural Introspection
SA-2	Appearance	ME-2	Operational transaction risk	SH-7	Convenience
SA-3	Linkage	ME-3	Compliance risk	SH-8	Security
SA-4	Content	ME-4	Reputational risk	SH-9	Adoption intension
SA-5	Incubate dimension	ME-5	Information security risk	MI-1	Innovativeness
SA-6	e-service quality	ME-6	Credit risk	MI-2	Trust in technology
SA-7	Active dimension	ME-7	Interest rate risk	MI-3	Concern for data privacy
SA-8	Reliability	ME-8	Liquidity risk	MI-4	Compatibility
SA-9	Efficiency	ME-9	Price risk	MI-5	Perceived usefulness
SA-10	Support	ME-10	Foreign exchange risk	MI-6	Social influence
SA-11	Communication			MI-7	Facilitating conditions
SA-12	Security			MI-8	Perceived risks
SA-13	Incentive			MI-9	Behaviour intension to accept tech.

Table 3. Components of proposed model

Level 1 (External Factors)	Sub-component	Description
Psychological Factors	Self-Efficacy	Self-efficacy is expected to play a significant role in technology adoption. High self-efficacy is expected to develop a positive customer attitude.
	<i>Technology anxiety</i>	Technology anxiety reflects the beliefs of usefulness and ease of use of a new technology in the context of TAM model. Technology anxieties also affect customer use and expertise with the self-service technology.
	<i>Perceived Behavior control</i>	Perceived behaviour control was found to be positively associated with the person's feelings and behaviour. Perceived behaviour control is considered a critical element of customer's attitudes and behaviour.
Quality of Service	<i>Appearance</i>	High quality appearance will lead to easily biometrics usage and attract Web surfers for initial and repeat visits.
	<i>Content</i>	Providing the right amount of appropriate updated information is a key element of e-service quality.
	<i>Reliability</i>	Reliability indicates the ability to achieve the promised service correctly and consistently, including regularity of updating the Web site. Web sites providing up-to-date information received high evaluation.
	<i>Support</i>	Offering user-friendly standards help pages are the first steps in offering high-quality support. Proposing free advice and suggestions such as, home-improvement advice and road planning is another positive element.
Information Security	<i>Privacy</i>	Consumers who do business with organizations are highly disturbed and vulnerable as their personal data can be compromised and abused. These growing privacy concerns have led to an even more emphasis on risk perception in decision-making as regards data disclosure .
	<i>Safety</i>	Online users generally trust in the safety of online banking transactions. The online customers trust more in Internet banking services than telephone banking facilities .
Risk	<i>Operational Transactional risk</i>	A great level of transaction risk can exist with Internet banking products, because of the need to have sophisticated internal controls and constant availability . (Mermod Y. A, 2011).

Table 4. Proposed model Intermediate Level 2.

Intermediate Level 2	Definition and remarks
Perceived Ease-of-Use	Perceived ease of use directly and indirectly affects usage through its impact on perceived usefulness through the attitude regarding using the Internet (Davis <i>et al.</i> , 1989, Barkhi L., <i>et al.</i> , 2007 and Amoroso D., <i>et al.</i> , 2012). It has also been indicated that there exists a direct relationship between perceived ease of use and both behavioural intention to use and overall satisfaction (He, F <i>et al.</i> , 2007).
Perceived Usefulness	The usefulness of carrying out transactions in a virtual environment such as online banking can be defined in terms of perceived benefits and the overall perceived advantages of using the virtual environment, such as the online banking.
Perceived Convenience	The perceived convenience is focused on resources such as time and effort required of the consumer in shopping for a product (Kazi, K. A 2013). Other researchers, however, expanded the concept of convenience to incorporate factors associated with the visual sight of the Internet banking (Black N J <i>et al.</i> , 2002)
Perceived Trust	Trust has been recommended as one of the major difficulties that delay individuals from adopting online related technology. It has been claimed in (Gerrard. P <i>et al.</i> , 2006) that trust is an essential requirement among bank customers in sight of rising cyber-crimes and identity thefts.

Table 5. Proposed model Final Level 3

Final Level 3	Definition and remarks
Acceptance of Biometrics	The Successful service delivery on behavioural issues can affect the customer loyalty in relation to other factors just like it has on client satisfaction (Aliyu, A. A., <i>et al.</i> , 2014). Banks are facing lots of challenges in using numerous new information services available in the market. Hence, they are developing a number of alternate delivery channels with the aim being to appeal tech-savvy clients, improving customers' expectations and ensuring customer loyalty (George A, <i>et al.</i> , 2014.)

Table 6. Proposed model components cross listing with six other models.

#	Proposed Robust (PR) model	TAM [22] TA- #	UTAUT [24] UT- #	SA [71] SA- #	SH [72] SH- #	MI [73] MI- #	ME [74] ME- #	Frequency with Rf. PR model
PR-1	Self-efficacy		UT-2	SA-9	SH-1		MI-1	4
PR-2	Technology anxiety				SH-3			1
PR-3	Perceived behaviour				SH-4			1
PR-4	Appearance							0
PR-5	Content			SA-4				1
PR-6	Reliability			SA-8				1
PR-7	Support							0
PR-8	Privacy						MI-3	1
PR-9	Safety			SA-12	SH-8			2
PR-10	Operational risk					ME-1	MI-8	2
PR-11	Perceived ease-of-use	TA-2		SA-1				1
PR-12	Perceived usefulness	TA-1		SA-10			MI-5	2
PR-13	Perceived convenience		UT-4	SA-2	SH-7		MI-7	4
PR-14	Perceived trust	TA-4	UT-5		SH-5		MI-2	4
PR-15	Acceptance of biometrics				SH-9		MI-9	2

Table 7. The hypotheses made in our research model are introduced below.

<u>Level 1</u>		<u>Level 2</u>	<u>Level 3</u>	<u>Hypothesis</u>	<u>Hypothesized Impact</u>	
<u>(main factors)</u>	<u>(sub-components)</u>				<u>Positive</u>	<u>Negative</u>
1. Psychological Factors	1. Self-efficacy	perceived ease-of-use		H1	✓	
	2. Technology anxiety	perceived usefulness		H2	✓	
	3. Perceived behavioural control	perceived convenience		H3	✓	
2. Quality of Service	1. Appearance	perceived ease-of-use		H4	✓	
	2. Content	perceived usefulness		H5	✓	
	3. Reliability	perceived convenience		H6	✓	
	4. Support					
3. Information Security	1. Privacy	perceived usefulness		H7	✓	
	2. Safety	perceived Trust		H8	✓	
4. Risk	Op. Trans. Risk	perceived Trust		H9		✓
		perceived ease-of-use		H10	✓	
		perceived usefulness	Acceptance of Biometrics	H11	✓	
		perceived convenience		H12	✓	
		perceived Trust		H13	✓	

3. Research questions and data collection

The research questions are divided into major and minor research questions.

(a) Major Research Question

- What are the factors that impact acceptance of biometrics within online banking in Kuwait?

(b) Minor Research Questions

1. What is the significance of psychological factors in the acceptance of biometrics in online banking in Kuwait?
2. What is the significance of quality of service factors in the acceptance of biometrics in online banking in Kuwait?
3. What is the significance of information security factors in the acceptance of biometrics in online banking in Kuwait?
4. What is the significance of operational-transactional risk on perceived trust in the acceptance of biometrics within online banking in Kuwait?
5. What is the significance of factors on the acceptance of biometrics within online banking in Kuwait?

We have used self-administered questionnaire based on the proposed research model was constructed, reviewed, and distributed via the online tool *SurveyMonkey.com*. The sample population for our research was customers using online banking in Kuwait. The questionnaire link was sent to the bank customers, through emails, what's App, Facebook and Twitter. Customers were selected at random. Clicking on the questionnaire took the respondent to the website with the questionnaire. The first page of the questionnaire had the cover page, and then followed by their knowledge and experience on biometrics. The next section contained the demographics. The final sections had the variables with their items. Prior to beginning the questionnaire and after the introduction letter, we had to ensure that the respondent was using online banking. This was because; the concept of biometrics was focused in banks and particularly in online banking. If the respondent answered yes then the rest of the questionnaire, beginning with the demographics was presented to them.

After a period of three weeks, a total of 398 responses were downloaded from the

SurveyMonkey.com website. These records were examined to ensure that all the necessary fields were entered. Records of respondents who are not using online banking were deleted from the file. A total of 96 such responses were removed from the Excel file. The final count of usable responses was 302. Those were entered into *SPSS* tool for generating various statistical analyses. Table 8 provides the demographic and the biometric exposure details of the respondents

4. Data analysis, findings and discussion

Table 9 provides the Cronbach's Alpha results. Data reliability has been carried out for each of the factors separately. All the factors showed above threshold data reliability, i.e. Alpha > 0.7.

5. Correlation analysis

We test the relationship between two variables using the significance and correlation values. Significance is established if the *p*-value is less than 0.05 (95% confidence level). For variables that indicate significance, the correlation between

them is studied on a scale ranges between -1 to +1. Table 10 summarizes the results obtained for the four independent variables: Psychological, Quality of service, Security, and Customer Perception.

5.1 Psychological Factors

Observations (please refer to Table 9):

1. **Self-Efficacy (PSELF)** has strong significance with all three perceived factors while having weak positive correlation (0.334, 0.312, and 0.341, respectively).
2. **Technology Anxiety (PTECHA)** has significance with the three perceived factors while having weak negative relationships (-0.162, -0.116, and -0.156, respectively).
3. **Behaviour Control (PBEHC)** has strong significance with PUSE and PCONV and standard significance with PEOU while having weak positive correlation with all three perceived factors (0.121, 0.267, and 0.323, respectively).

Table 8. Demographics and Biometric exposure of respondents

Measure	Attribute	%age
Gender	Male	42%
	Female	58%
Nationality	Kuwaiti	70%
	Non-Kuwaiti	30%
Age	Under 20 years	54%
	20-30 years	29%
	31-40 years	14%
	Above 40 years	3%
Education	High School	26%
	Bachelor degree	49%
	Master degree	25%
Biometrics Knowledge	Above Average	12%
	Average	57%
	Below Average	23%
	None	8%
Biometrics Use	Fingerprint	57%
	Voice recognition	10%
	Hand geometry	5%
	Facial recognition	3%
	Iris (eye)	5%
	None	17%
	Others	2%

Table 9. Data Reliability Test Results.

Variable	Alpha	Number of Items
Psychological Factors		
Self-Efficacy	0.788	3
Technology Anxiety	0.820	3
Perceived Behaviour Control	0.793	3
Quality of Service		
Appearance	0.808	3
Content	0.893	4
Reliability	0.806	4
Support	0.883	4
Information Security		
Privacy	0.775	2
Safety	0.923	3
Risk		
Operational Transaction Risk	.717	4
Customer Perception		
Perceived Ease-of-Use	0.879	3
Perceived Usefulness	0.818	3
Perceived Convenience	0.772	3
Perceived Trust	0.888	3

Table 10. The Correlation analysis of psychological factor

Independent Variables ↓	perceived ease-of-use (PEOU)		perceived usefulness (PUSE)		perceived convenience (PCONV)		Perceived trust (PTRUS)	
	Significance	Correlation	Significance	Correlation	Significance	Correlation	Significance	Correlation
1. Psychological Factors								
Self-Efficacy (PSELF)	0.000	0.334	0.000	0.312	0.000	0.341	Does not apply	
Technology Anxiety (PTECHA)	0.005	-0.162	0.043	-0.116	0.007	-0.156		
Behavioural Control (PBEHC)	0.035	0.121	0.000	0.267	0.000	0.323		
2. Quality of Service								
Appearance (QAPPR)	0.003	0.173	0.000	0.221	0.000	0.314	Does not apply	
Contents (QCONT)	0.000	0.205	0.001	0.190	0.000	0.420		
Reliability (QREL)	0.0000	0.312	0.000	0.277	0.000	0.430		
Support (QTECHS)	0.000	0.215	0.000	0.261	0.000	0.359		
3. Security								
Privacy (IPRIV)	0.000	0.273	Does not apply		Does not apply		0.000	0.273
Safety (ISAFE)	0.000	0.327					0.000	0.210
4. Custom. Per.								
Biometrics Adoption (AOBIO)	0.000	0.234	0.000	0.367	0.000	0.482	0.000	0.529

5.2 Quality of Service

Observations (please refer to Table 9):

- 1. Appearance (QAPPR):** The correlations indicated weak positive correlation with all three perceived factors (0.173, 0.221, and 0.314, respectively).
- 2. Content (QCONT):** The correlations are weak for all three perceived factors (0.205, 0.190, and 0.420, respectively).
- 3. Reliability (QREL):** The correlation indicates weak positive relationships 0.312, 0.277, and 0.430, respectively).
- 4. Support (QTECHS)** has strong significance with all three perceived factors while having weak positive correlations (0.215, 0.26, and 0.359).

5.3 Information Security

Observations (please refer to Table 9):

- 1. Privacy (IPRIV)** has strong significance with both PUSE and PTRUS but weak positive correlation (0.237 and 0.273).
- 2. Safety (ISAFE)** has strong significance with both PUSE and PTRUS, but weak positive correlation (0.327 and 0.210).

5.4 Risk

In risk, the focus was on operational-transactional risk (ROTR) and its impact on perceived trust (PTRUS). Based on the result, there is no significance with trust. The results therefore indicate that the customers’ concern of losing money, or privacy information, or internet hackers, has no impact in the perceived trust.

5.5 Correlation Analysis Overall Outcome:

customer perception about the ease of using biometrics, its usefulness, and the convenience of using biometrics through various platforms, such as smartphone and tablet devices, is positively related to the biometrics use in online banking in Kuwait.

6. Regression analysis

The regression analysis tests the significance of the independent variables to the dependent variable and is also used to test the hypothesis. After we checked that all variables included are normally distributed we are using the liner regression which provides three output tables. These are the model summary table, the ANOVA table and the Coefficients table. In the model summary, we observe the R-square value which is the percentage of the response variable variation that is explained by the linear model. The ANOVA table provides the significance for the model. The significance (p-value) should be less than 0.05 or (high F-value). The higher the F-value the stronger the significance. The Coefficient results indicate the significance of each of the independent variables to the dependent variable. There are two values that we focus on in this tables. These are the significance and the Beta value. The beta values indicate if the independent variable has a positive or negative impact on the dependent variable and the value also provides understanding into the strength of this impact compared with the other independent variables. The significance of the independent variables (high t-value or p-value less than 0.05) indicate the importance of the independent variables.

Based on these rules, we study the following regression Models:

1. Psychological factors (self-efficacy, technology anxiety, and perceived behavioural control) to perceived ease-of use (PEOU), perceived usefulness (PUSE), and perceived convenience (PCONV).
2. Quality of Service (appearance, content, reliability, and support) to perceived ease-of use (PEOU), perceived usefulness (PUSE), and perceived convenience (PCONV).

3. Information security (privacy and safety) to perceived usefulness (PUSE), and perceived trust (PTRUS).
4. Risk (operational-transactional risk) to perceived trust (PTRUS).
5. Customers' Perception of Technology (PEOU, PUSE, PCONV, and PTRUS) on adoption of biometrics (AOBIO)

6.1 Regression Model-1: Psychological-Factors

(a) Regression for PEOU

In this regression we are testing the significance of (1) Self-Efficacy, (2) Technology Anxiety, and (3) Perceived Behaviour Control (Independent variables) on Perceived Ease-of Use (PEOU) (Dependent variable). The hypothesis that will tested is:

H1: The perceived ease-of-use of biometrics in online banking will have positive impact based on the psychological factors of online banking customers, such as, self-efficacy, technology anxiety and perceived behavioural control. Below is the captured data.

Model		Standardized Coefficients	t	Sig.
		Beta		
1	(Constant)	3.093	10.386	.000
	Self-Efficacy	.314	5.404	.000
	Technology Anxiety	-.090	-1.583	.114
	Perceived Behaviour Control	-.003	-.051	.959

The above table shows that; only self-efficacy shows strong significance with a beta of 0.314 with significant p-value less than 0.05 and high test statistic t-value. Based on these results, we can state that hypothesis H1 is partially accepted with self efficacy ($\beta=0.314$).

(b) Regression for PUSE

In this regression we are testing the significance of (1) Self-Efficacy, (2) Technology Anxiety, and (3) Perceived Behaviour Control (Independent

variables) on Perceived Usefulness (Dependent variable). The hypothesis that will be tested is:

H2: The perceived usefulness of biometrics in online banking will have positive impact based on the psychological factors of online banking customers, such as, self-efficacy, technology anxiety and perceived behavioural control. Below is the captured data.

Model	Standardized Coefficients	t	Sig.
	Beta		
1 (Constant)	2.426	9.363	.000
Self-Efficacy	.250	4.326	.000
Technology Anxiety	-.013	-.221	.825
Perceived	.183	3.137	.002

The coefficient results indicate that only self efficacy is significant with perceived usefulness. There we can state that hypothesis H2 is **partially accepted** with self-efficacy ($\beta=.250$).

(c) Regression for PCONV

In this regression we are testing the significance of (1) Self-Efficacy, (2) Technology Anxiety, and (3) Perceived Behaviour Control (Independent variables) on Perceived Convenience (Dependent variable). The hypothesis that will be tested is:

H3: The perceived convenience of biometrics in online banking will have positive impact based on the psychological factors of online banking customers, such as, self-efficacy, technology anxiety and perceived behavioural control. Below is the captured data.

Model	Standardized Coefficients	t	Sig.
	Beta		
1 (Constant)	2.499	9.424	.000
Self-Efficacy	.258	4.556	.000
Technology Anxiety	-.039	-.703	.483
Perceived Behaviour	.230	4.041	.000

Based on the coefficient results, self-efficacy and perceived convenience of biometrics in online banking will have positive impact based on the psychological factors of online banking customers, such as, self-efficacy, technology anxiety and perceived behavioural control) is **partially accepted** with self-efficacy ($\beta=.258$) and perceived behavioural control ($\beta=.230$). Based on the beta values, the stronger impact is from self efficacy.

Based on the three regression analysis that we have carried out, the results show that for psychological factors of the customer, the stronger impact is from self-efficacy when studying customers' perception of biometric adoption and perceived behavioural control also plays a significant role.

6.2 Regression 2: Quality of service

(a) Regression for PEOU

In this regression, we are testing the significance of four independent variables, which are, (1) Appearance, (2) Content, (3) Reliability, and, (4) Support to Perceived Ease-of-Use (dependent variable). The hypothesis that will be tested here is:

H4: The perceived ease-of-use of biometrics in online banking will have positive impact based on the quality of service of online banking such as appearance, content, reliability and support that is received by online banking customers from the banks. Below is the captured data.

Model	Standardized Coefficients	t	Sig.
	Beta		
1 (Constant)	2.181	7.099	.000
Appearance	.084	1.448	.149
Content	-.056	-.724	.470
Reliability	.282	3.556	.000
Support	.094	1.517	.130

The coefficient results show that only reliability shows significance with perceived ease-of-use. Therefore, we can state that hypothesis H4 is **partially accepted** with reliability ($\beta=.282$).

(b) Regression for PUSE

perceived behavioural control have strong significance with perceived convenience. Therefore, we can state that hypothesis H3 (The In this regression, we are testing the significance of four independent variables, which are, (1) Appearance, (2) Content, (3) Reliability, and, (4) Support to Perceived Usefulness (dependent variable). The hypothesis that will be tested here is:

H5: The perceived usefulness of biometrics in online banking will have positive impact based on the quality of service of online banking such as appearance, content, reliability and support that is received by online banking customers from the banks. Below is the captured data.

Model		Standardized Coefficients		
		Beta		
1	(Constant)	2.073	7.751	.000
	Appearance	.145	2.498	.013
	Content	-.065	-.844	.399
	Reliability	.202	2.564	.011
	Support	.168	2.710	.007

Based on the coefficient results, appearance, reliability and support indicate significance. Therefore, we can state that hypothesis H5 is **partially accepted** with appearance ($\beta=.145$), reliability ($\beta=.202$) and support ($\beta=.168$). Based on the beta values, we can state that the stronger impact of quality of service on perceived usefulness is from reliability with a beta of 0.202.

(c) Regression for PCONV

In this regression, we are testing the significance of four independent variables, which are, (1) Appearance, (2) Content, (3) Reliability, and, (4) Support to Perceived Convenience (dependent variable). The hypothesis that will be tested here is:

H6: The perceived convenience of biometrics in online banking will have positive impact based on the quality of service of online banking such as appearance, content, reliability and support that is received by online banking customers from the

banks. Below is the captured data.

Model		Standardized		
		Beta		
1	(Constant)	1.390	5.426	.000
	Appearance	.170	3.218	.001
	Content	.169	2.395	.017
	Reliability	.181	2.510	.013
	Support	.173	3.059	.002

Based on the coefficient results, all the four quality of service variables are significant with perceived convenience. Therefore, we can state that hypothesis H6 is **accepted** with appearance ($\beta=.170$), content ($\beta=.169$), reliability ($\beta=.181$) and support ($\beta=.173$). Based on the beta value, we can understand that the stronger impact of quality of service on perceived convenience is from reliability with a beta of 0.181.

Based on the regression results, we can state that out of the four quality of service factors that we have studied, the stronger impact is from reliability.

6.3 Regression 3: Information Security**(a) Regression for Privacy**

In this regression we are testing the following hypothesis:

H7: The perceived usefulness of biometrics in online banking will have positive impact based on the information security factors such as privacy and safety and lead to the acceptance of biometrics in online banking. Below is the captured data.

Model		Standardized Coefficients	t	Sig.
		Beta		
1	(Constant)	2.601	13.677	.000
	Privacy	.052	.735	.463
	Safety	.294	4.176	.000

Based on the coefficient results, only Safety is significant shows strong significance with a beta of 0.294. Therefore, we can state that hypothesis H7 is **partially accepted** with Safety ($\beta=.294$).

(b) Regression for Safety

This regression tests the following hypothesis:

H8: The perceived trust of biometrics in online banking will have positive impact based on the information security factors such as privacy and safety and lead to the acceptance of biometrics in online banking. Below is the captured data.

Model	Standardized Coefficients	t	Sig.
1 (Constant)	2.951	12.353	.000
Privacy	.232	3.246	.001
Safety	.064	.889	.375

The coefficient results indicate that only privacy has strong significance with a beta of 0.232. Therefore, we can state that hypothesis H8 is **partially accepted** with privacy ($\beta=.232$). Based on the results we state that for information security, safety impacts perceived usefulness and privacy impacts perceived trust. Therefore, we can state that privacy and safety are both important factors in customer perception of using biometrics.

6.4 Regression 4: Risk

In this regression, we study the significance of Operational Transaction Risk (independent variable) on perceived trust (dependent variable). The hypothesis that will be tested here is:

H9: The operational-transactional risk will have negative significance with perceived trust and lead to the acceptance of biometrics in online banking. Below is the captured data.

Model	Standardized Coefficients	t	Sig.
1 (Constant)	3.851	19.704	.000
Operational Transaction Risk	.053	.922	.357

This is because operational-transaction risk is not significant with perceived trust. The results here indicate that hypothesis H9 is **rejected**.

The results here indicate that risk, specifically, operational-transactional risk do not play a significant role in customers' perception towards adoption of biometrics.

6.5 Customers' Perception of Technology

The regression studies the significance of customer perception, such as (1) ease-of-use, (2) usefulness, (3) convenience and (4) trust (independent variables) on acceptance of biometrics (dependent variable). The results will be used to test the following hypotheses:

H10: Online banking customers who are concerned about the perceived ease-of-use of online banking are more likely to accept the use of biometrics in online banking.

H11: Online banking customers who are concerned about the perceived usefulness of online banking are more likely to accept the use of biometrics in online banking.

H12: Online banking customers who focus on the perceived convenience of online banking are more likely to accept the use of biometrics in online banking.

H13: Online banking customers who are concerned about the perceived trust in online banking are more likely to accept the use of biometrics in online banking.

Below is the captured data.

Model	Standardized Coefficients	t	Sig.
1 (Constant)	1.082	4.384	.000
Perceived Ease -of-Use	.006	.116	.908
Perceived Usefulness	.087	1.548	.123
Perceived Convenience	.256	4.283	.000
Perceived Trust	.370	6.791	.000

The coefficient results and indicates that

perceived convenience and perceived trust. Based on the results we can answer the following hypotheses:

H10: Online banking customers who are concerned about the perceived ease-of-use of online banking are more likely to accept the use of biometrics in online banking is **rejected**.

H11: Online banking customers who are concerned about the perceived usefulness of online banking are more likely to accept the use of biometrics in online banking is **rejected**.

H12: Online banking customers who focus on the perceived convenience of online banking are more likely to accept the use of biometrics in online banking is **accepted** with beta of 0.256

H13: Online banking customers who are concerned about the perceived trust in online banking are more likely to accept the use of biometrics in online banking is **accepted** with beta of 0.370.

7. Test for demographics

Two types of tests were used: the independent sample t-test and the one-way ANOVA test.

7.1 T-test for Gender

The results in Table 11 show significance of gender with only the perceived ease-of-use (PUSE) and the perceived trust (PTRUS).

7.2 One-way ANOVA for Education

The results in Table 12 show significance only with perceived usefulness (PUSE). The post-hoc

Bonferroni test results is shown in Table 13. It is clear that people with high school degree and Bachelor's degree are more inclined towards the adoption of biometrics in online banking based on its usefulness. This is consistent with the earlier findings of age where younger generation showed significance.

8. Conclusions and direction for future research

In this paper we have introduced a model for measuring the customers' acceptance of biometrics. Data was collected based on survey using self administered questionnaire distributed through *SurveyMonkey.com* platform. A total of 500 invitations were sent and 302 valid responses were received. The data was analysed using *SPSS* software tool. Analyses such as descriptive, correlation, regression, t-test and one-way ANOVA were conducted on the collected data. The various analyses and tests conducted in the study revealed that self-efficacy (psychological factors) and reliability (quality of service) are the significant factors that impact the perceived ease-of-use. For perceived usefulness, we found that self-efficacy (psychological factors), reliability, appearance, and support (quality of service), and safety (information security) are the impacting factors. Privacy was identified as the significant factor for perceived trust. With regard to acceptance of biometrics, the impact was from perceived convenience and perceived trust. It should be noted that implementation of Biometrics in online banking should be based on data collected from at least two other constituents: the information technology specialists in banks and the banking business decision makers/managers.

Table 11. T-Test for Gender.

Dependent Variable	Gender	T	p-value	Significance
PEOU	Male	0.800	0.424	Not Significant
	Female	0.79	0.430	
PUSE	Male	4.055	0.000	Significant
	Female	4.193	0.000	
PCONV	Male	1.514	0.131	Not Significant
	Female	1.554	0.121	
PTRUST	Male	2.667	0.008	Significant
	Female	2.726	0.007	
BOBIO	Male	0.885	0.377	Not Significant
	Female	0.911	0.363	

Table 12. ANOVA for Education

Dependent Variable	Gender	F	p-value	Significance
PEOU	Male	1.78	0.171	Not Significant
	Female			
PUSE	Male	3.080	0.047	Significant
	Female			
PCONV	Male	0.137	0.872	Not Significant
	Female			
PTRUST	Male	2.070	0.128	Not Significant
	Female			
BOBIO	Male	0.508	0.602	Not Significant
	Female			

Table 13. Post-hoc Bonferroni for Education

	Mean Difference	p-value	Significance
High school & Bachelor	0.20865	0.041	Significant
High schools & Master	0.13757	0.469	Not Significant
Bachelor & Master	0.07107	1.000	Not Significant

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